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Bold Open-Caisson Method in Denmark

Row of steel pipes around concrete caisson and integral with it provides dredging wells and cofferdam wall for piers in 100 ft. of water for the great steel and concrete bridge across the Strait of Little Belt

By Kai Kaat-Jensen

Civil Engineer, Copenhagen, Denmark.

RECENT COMPLETION of the concrete-arch approaches and the channel foundations for the Lillebaelt (Little Belt) bridge in Denmark marks a long step in the prosecution of one of the most important bridge-building operations in Europe. The foundation work is particularly notable as introducing a bold method of open caisson work involving the use of a novel concrete caisson built upside down on the shore, floated into place and sunk through dredging wells formed by a row of steel pipes built into the exterior wall of the caisson and serving as a cofferdam for the pier construction. The proposed method of steel erection for the five-span 2,700-ft. cantilever structure over the channel is also noteworthy. Denmark, as reference to the map (Fig. 3) will show, consists of the mainland peninsula of Jutland extending directly north from German Schleswig-Holstein of the two large islands of Funen and Zealand, and numerous smaller islands. Jutland is separated from Funen (lying directly east) by the strait of the sea known as Little Belt, and Zealand directly east of Funen is separated from it by the wider strait known as Great Belt. Copenhagen, the national capital, is on the east coast of Zealand.

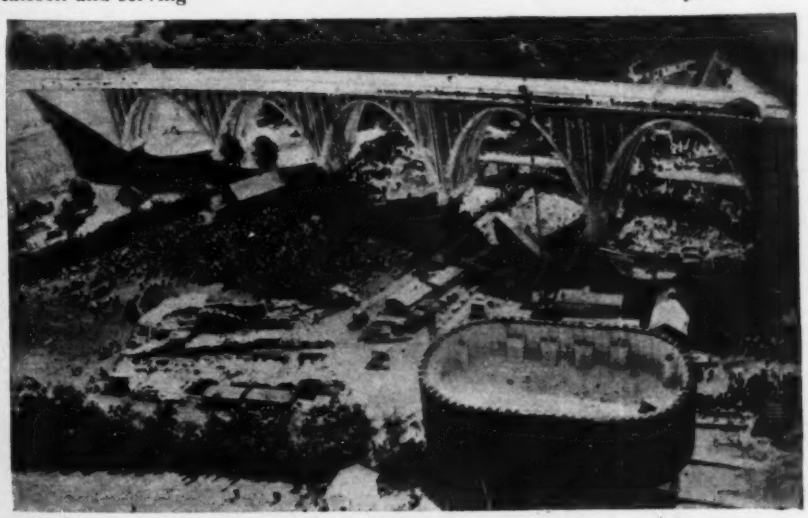


Fig. 1—Completed approach spans of Little Belt bridge on mainland end and view of caisson launching. The exterior wall of steel pipes, which forms the notable characteristic of the caisson, is plainly shown. The caisson is upside down, and the concrete diaphragm within it is the roof of the working chamber.

At present railway and road traffic between Zealand and Funen and the mainland of Jutland and continental Europe is by ferries across Great Belt and Little Belt. Great Belt is too wide to be bridged, but for a long time a bridge across Little Belt has been under consideration. In 1928-29, following great increases in automobile traffic, an agreement was arrived at by which the bridge would be financed by the Danish State Railways and contributions from the road fund created by revenues from motor-vehicle taxes. Construction was begun about the middle of 1930. The bridge is a five-span cantilever structure with a channel length of 2,700 ft. With the concrete-arch approaches its total length is 3,895 ft. It provides for a double-track railway and a roadway between trusses and for a wide sidewalk outside the truss

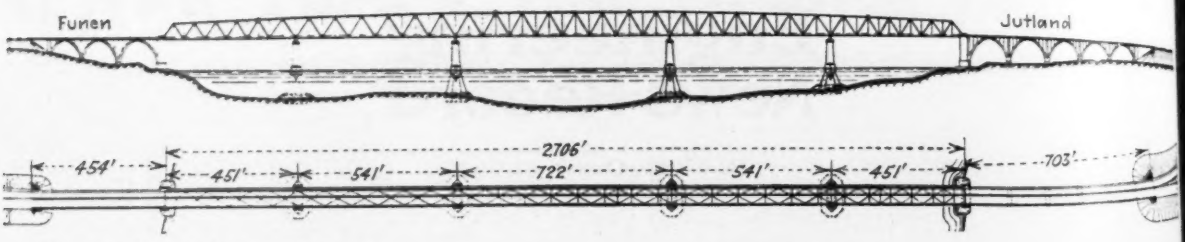


Fig. 2—Cantilever bridge for railway and road traffic across the Little Belt between the mainland and the island of Funen in Denmark.

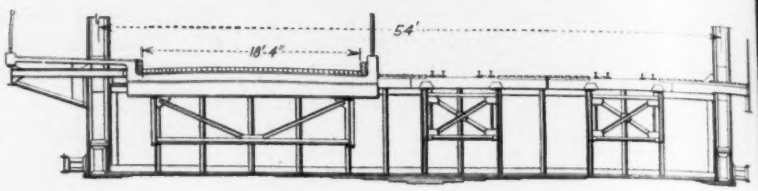


Fig. 4—Cross-section of Little Belt bridge, showing floor construction for double-track railway, roadway and sidewalk.

on one side. Fig. 2 shows the span arrangement, and Fig. 4 is a transverse section. Transverse and longitudinal main dimensions are shown on the drawings.

Development of design

Several proposed designs were considered, including those submitted by the bidders for the construction. Comparison of these designs disclosed that

Fig. 3—Location of the Little Belt bridge which will give Copenhagen, situated on an island, easier access to the mainland areas of Europe.

the suspension types would cost some 28,000,000 Danish crowns, while the cantilever designs ranged between 21,000,000 and 22,000,000. It appeared that the least expensive design would be that shown in Fig. 2. Architecturally this design was also considered to be the most attractive.

Various proposals were also considered as to kind of steel and methods of erection. The weight of steel ranged from 14,000 to 15,000 tons, depending on the kind. Several kinds were considered, including silicon steel, but selection was finally made of a silicon-copper steel, with an ultimate tensile strength between 80,000 and 90,000 lb. per sq.in.

The several proposed methods of erection were finally sifted down to one proposed by the Danish State Railways and illustrated by Fig. 5. Upon completion of two of the piers, falsework brackets were to be attached to them in line with the bridge and wide enough to support two panels of the trusses, as shown at *a*, Fig. 5. Derricks mounted on the falseworks brackets were then to erect two panels of the steelwork, after which they were be be lifted to the top chords of the erected panels. In this position they were to extend the brackets another panel length, as shown by *b*, Fig. 5. Extension of the steelwork both ways from the piers was then to begin and continue, as shown by *c* and *d*, Fig. 5. When the second two piers were completed the processes just described were to be repeated and the steelwork was to be closed up, as shown by *e*, *f* and *g*, Fig. 5.

The method of steel erection proposed was accepted by the contractor, but until later no estimate of its success is possible. The present article therefore gives only some account of the approach-arch construction and general details of the unusual methods of caisson construction.

A view of the completed approach on the Jutland shore and of one of the caissons being launched is given in Fig. 1. Briefly the approach arches consist of four ribs, two on one side about 10 ft. wide, each carrying a railway

Fig. 5—Schematic plan of steel erection for channel spans of Little Belt bridge in Denmark.

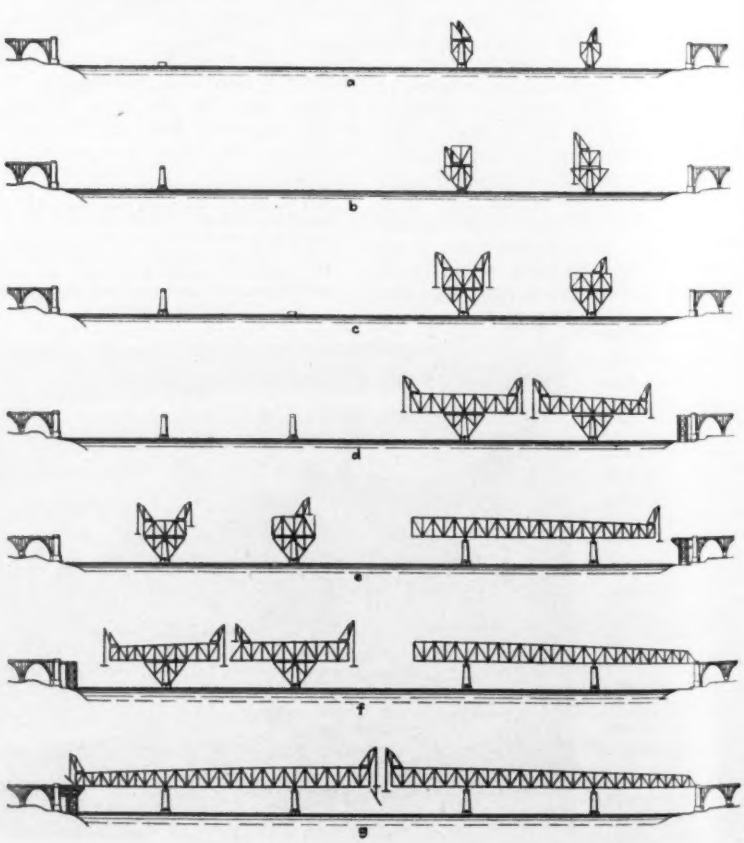


Fig. 6—Arch ribs under construction for mainland approach spans; each wide rib carries a railway track, and the two narrow ribs carry the roadway.

track, and two on the other side about 5 ft. wide, carrying the roadway. Fig. 6 shows the arch ribs under construction for the Jutland approach. All the ribs have the same arc to simplify centering and falsework.

Substructure plan

At the crossing the maximum depth of water is about 130 ft. and the banks rise rather sharply to about 56 ft. above water level. The bottom is clay, considered to give a good foundation. The water conditions are very irregular, depending on the tide, the winds in the North and the Baltic Seas and the flow of fresh water from the Baltic. While the tide creates north and south currents of about 1¾ ft. a second, the other two influences may create a north-flowing current of about the same speed. Changes in current occur frequently and often with little warning. At times parallel currents in opposite directions are experienced. Ice conditions are not ordinarily bad, as the currents break up the floes and prevent packs. The prevailing winds are west and east and are generally light.

Fig. 7 — Caisson for channel span piers being constructed bottom side up on the launching ways.

With these conditions to be met in the channel foundations, it was first proposed to employ the usual pneumatic-caisson process. On a proposal by Grün & Bilfinger, one of the partner firms of the associated contractors for the bridge, a change was made to an open-caisson process invented by them.

The plans called for foundations bottomed about 21 ft. below the channel bottom. Except at one foundation where it was about 79 ft., the depth of water at the piers was 98 ft. The height of

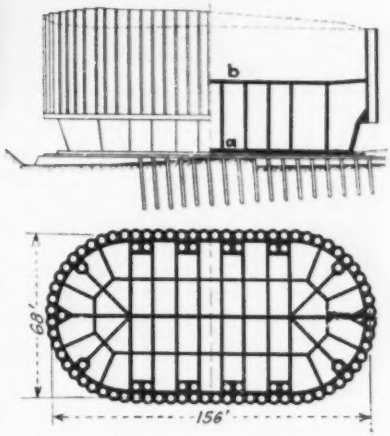


Fig. 8—Diagram plan and sectional elevation of part of caisson constructed on launching ways on land.

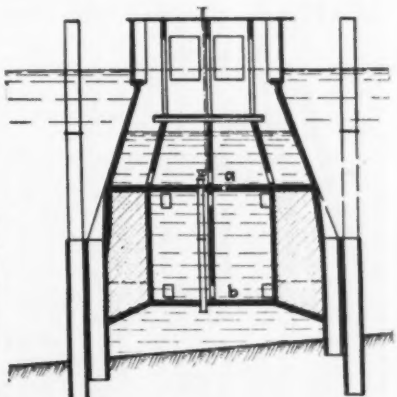


Fig. 9—Diagram cross-section of completed caisson in final position for sinking.

the piers above water was 108 ft., making the total height from foundation bed to pier top 227 ft. At the maximum section the trusses were 85 ft. deep, bringing the top of the structure 312 ft. above the deepest foundation.

Caisson construction

As designed, the caissons had a bearing area of 1,128 sq.yd. and weighed up to the base of the pier shaft about 55,000 tons each. One of the caissons being launched is shown by Fig. 1, and Fig. 7 shows a caisson being constructed on the ways and indicates the appearance of the waterway from the Jutland shore.

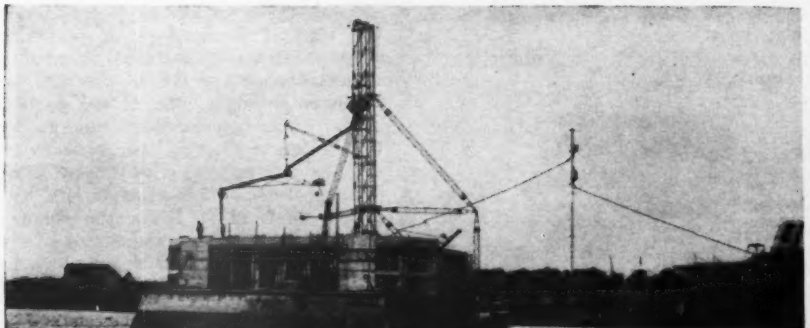


Fig. 10—Floating plant for concreting caissons after launching.

The construction of the caisson is best explained by the diagram plan and sectional elevation of Fig. 8. Fig. 9 is a cross-section of the full caisson structure.

The caisson is a cellular structure of reinforced concrete with an outer wall of steel pipes incased in concrete and bound integrally with the partition walls and working chamber roof of the lower part of the cassion, as shown by Fig. 8. In building the caisson upward after launching, the pipe wall is extended upward to form a cofferdam, as shown by Fig. 9. The cofferdam pipes are not incased.

The part of the caisson built on shore includes the second roof *a*, Fig. 9, and all parts below it, including the working chamber roof *b*, Fig. 9. This part, as shown in Fig. 7, is built upside down with the roof *a* resting on the ways and pipe walls sticking up, as shown by Fig. 7. This arrangement permits easy launching, which would be difficult if the caisson were built right side up, since the bottom of the pipe wall is shaped (Fig. 7) to the profile of the channel bottom as determined by underwater surveys.

After launching, the caisson, completed as shown in Fig. 8, is righted by filling the pipes and cells on one side with water until it tips over top up. With the caisson righted the unusual method followed in building it up is to ground it by water ballast in shallow water and build up, then float it to deeper water and ground it again and continue construction and repeat these processes until the structure is completed. Then it is floated to the pier location and sunk by dredging inside the pipes. The concreting is done by the floating plant shown by Fig. 10.

The construction of the Little Belt bridge is under the direction of the Danish State Railways. The contractors are the Danish firm of Monberg & Thorsen, which has associated with itself for this work the German firms of Fried, Krupp, Grün & Bulfinger, and Louis Eilers.

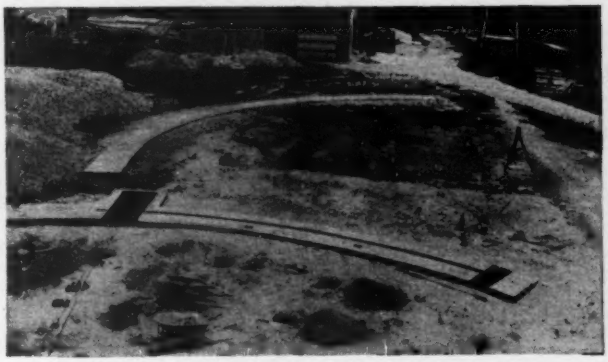
Casting and Fitting Panels for Baha'i Temple Dome Shell

PREPARATORY work is now in progress for clothing the bare dome superstructure of the Baha'i Temple in Wilmette, Ill., with the "fairy envelope" required by the remarkable design of the architect, the late Louis Bourgeois. This work involves some interesting special procedure. The envelope (for the dome structure itself, see *ENR*, Jan. 8, 1931, p. 75) is to be composed of panels of precast architectural concrete modeled by the John J. Earley studio, Washington, D. C., under direction of Allen B. McDaniel for The Research Service, Washington, as managing engineers for the trustees of the temple.

Dome reproduced in falsework

Work on the dome ornamentation has been going on since the middle of June at the Earley plant in Rosslyn, Va. To prepare for the panel molding, a timber framework (Fig. 2) was built to reproduce accurately one main panel of the outer structural framework of the dome, as it is built at Wilmette. The framework rests on a concrete slab foundation, and the timber ribs and girts were laid out with all possible precision on individual concrete layout slabs on which the rib and girt circles were scribed. The completed wooden structure was finally checked up against the structural-steel dome at Wilmette by wooden templets fitted to the former and transported to Wilmette, where they were found to fit the dome frame within ¼-in. maximum departure.

Fig. 1—To insure accuracy in laying out the ribs and girts of the wooden dome, a pair of concrete layout slabs was built and the circles were scribed on them as guide lines.



Panel sections

The panels will be 5½ in. thick and of sizes to give a gross weight of about 2 tons each. The method of making the sections consists of modeling the perforated ornamentation in clay, taking a rough plaster cast, preparing a plaster of paris positive model, making plaster of paris molds from this and finally casting in these molds the finished concrete panels. Each panel will be reinforced with welded high-strength reinforcement, and the bonding of the reinforcement at the edges will make the whole envelope integral.

Fig. 2—At Rosslyn, Va., a wooden frame has been built as an exact replica of the outer face of the steel temple dome at Wilmette, Ill. Concrete shell panels cast at Rosslyn are carefully fitted to the wooden dome before being shipped to Wilmette.

Contraction Joints of Pardee Dam Grouted a Second Time

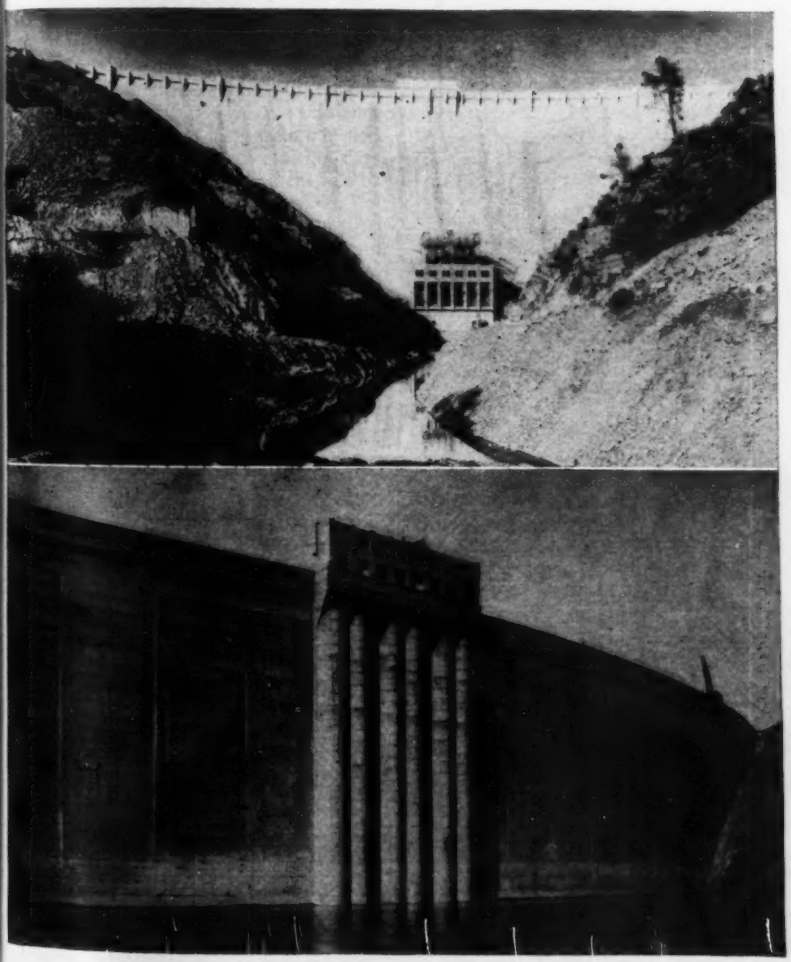
By F. W. Hanna

Chief Engineer and General Manager, East Bay Municipal Utility District, Oakland, Calif.

CONTINUED COOLING and shrinkage of the Pardee Dam, following the first grouting at the time the structure was completed in 1929, made a second grouting advisable to reduce seepage. This regrouting, completed early this year, has been effective in reducing seepage with reservoir full to 0.85 sec.ft., as compared to a seepage of 2.80 sec.ft. at the time of first filling, which followed the original grouting. A general description of the construction of Pardee Dam appeared in *Engineering News-Record* of Feb. 14, 1929, p. 258 and a detailed description of the contraction joints and first grouting appeared in the issue of March 21, 1929, p. 457.

Briefly the dam is 358 ft. high from the lowest concrete to top of parapet wall. To a height of 178 ft. the contraction joints are spaced at 150-ft. intervals; from this elevation to a height of 279 ft. a 75-ft. spacing is used, and from this level to the top of the dam the spacing is 37½ ft. The original grouting of the contraction joints was done before the dam was put into service. Grout was placed under a pressure of 100 lb., and 413 bbl. of cement were used. When the reservoir was filled, the maximum seepage into the drainage gallery was 2.8 sec.ft., and that through the dam and the abutments appearing at the downstream toe was 0.05 sec.ft.

Thermocouples were placed in the dam on one level at about mid-height. Five thermometers were used, one at the center, one about 45 ft. each side of this and another pair 10 ft. farther out from the center, the latter two being 2 ft. from the up- and downstream faces of the dam. These thermocouples indicated an initial internal temperature at the center of the dam of 79 deg. F. This temperature rose to a maximum of 102 deg. F. and has at present receded to 79 deg. Naturally this decrease in temperature has considerably widened the contraction joints.



Up- and down-stream faces of the curved gravity type Pardee Dam on the Mokelumne River which impounds water for nine California cities.

Before starting the second grouting of the dam, 2-in. holes were drilled at 20-ft. intervals in all vertical joints in the downstream face of the dam and at elevations of approximately 50, 75 and 100 ft. below the top within the middle half of the upstream face. All of these holes were driven at angles of 45 deg. with the faces of the contraction joints and were directed to cross the contraction joints 1 ft. behind the galvanized-iron grout stops placed in the concrete across the contraction joints at the time of construction. These grout stops are located 2 ft. from the downstream face and 8 ft. from the upstream face of the dam.

Holes were also drilled from the inspection gallery across the contraction joints, and the original grouting holes on top of the dam were opened by redrilling. To provide for forcing the grout through the drill holes without back leakage, 2-in. pipes threaded for connection with the grout machine were inserted, and the space around them was thoroughly calked with lead wool.

The drilling and grouting on the downstream face of the dam were done from a traveling scaffold fitted with revolving casters for movement over the face of the dam. This platform was suspended from a movable head block on top of the parapet wall. Vertical movements were made with an electric hoist. Drilling and grouting on the upstream face of the dam were done from a suspended scaffold and a barge with a 20-ft. tower.

The second grouting of the dam started in December, 1931, and was completed in April, 1932. The mixture varied from one part cement and one part water, to one part cement and four parts water. Air was supplied from portable compressors with pressures ranging from 5 to 120 lb., and care was used to avoid moving the shorter blocks or opening up the contraction joints excessively. Joints near the middle of the dam were first grouted from the gallery and upstream holes and later through the downstream holes. The work then proceeded from the center of the dam toward the abutments. In the regrouting 425 bbl. of cement were used.

This second grouting proved very effective in reducing seepage through the dam; maximum seepage with reservoir full during the present year is 0.85 sec.ft. as against 2.8 sec.ft. at the first filling. Of the present seepage 0.82 sec.ft. is collected in the drainage gallery.

The dam has not yet reached the average seasonal temperature, and it will cool and contract still further. In case this subsequent contraction is sufficient to cause much increase in seepage, it is proposed to do additional grouting.

Oiling Devices and Lubricants for Air Tools

Recent invention has taken the important task of lubricating air tools from the hands of the operator and made it regular and automatic

By James D. Clower
Assistant Professor of Machine Design, Virginia Polytechnic Institute, Blacksburg, Va.

LUBRICATION is unquestionably the most important single factor influencing the successful and reliable operation of paving breakers, clay diggers, backfill tampers and other air-driven tools of contractors. In too many instances contractors either do not realize the importance of correct lubrication of these machines or else are negligent of their lubrication. Correct lubrication not only embraces the selection of a correct oil for the service but also a proper method of application.

The direct and indirect benefits arising from practicing correct lubrication methods are numerous. The most important ones, however, may be summarized briefly as follows:

1. Increased output by decreasing frictional resistance between the various rubbing parts, particularly between the piston and the cylinder.
2. Reduced air consumption by maintaining an effective oil seal between the piston and cylinder, thereby preventing air blow-by.
3. Minimization of part renewals due to wear by maintaining protecting oil films between the different rubbing surfaces.
4. Prolonged useful life of machine by preventing "dry machine" during periods of operation and rusting during idleness.

These items obviously affect in turn such important costs as production, power, maintenance, depreciation and lubrication of tools.

Methods of application

The method employed for applying a lubricant to a concrete buster, a sheeting driver or a backfill tamper is as important and perhaps more important than the lubricant itself. Manifestly, the method employed should insure a uniform and regular oil feed at all times, for the best oil manufactured cannot provide effective lubrication if it is applied haphazardly at irregular intervals.

Three methods are quite generally employed for supplying the lubricant: (1) hand oiling, (2) impulse oilers and (3) air-line oilers.

Hand Oiling—Backfill tampers, clay diggers and other comparatively light machines are in general hand-oiled, no other means being provided. By this method the oil is poured at frequent intervals into the hose connection at the tool. The air stream is depended upon to carry the oil into the machine and distribute it over the frictional surfaces.

It is obvious that this method is entirely subject to the human element. Operators usually perform this duty at the beginning of the shift, but in their eagerness to get in the round they often neglect to re-oil during the shift. For correct lubrication it is essential that oil be applied once every hour while the machine is operating.

As it is usually practiced, hand oiling is very inefficient, wasteful and unreliable, as much more oil than is necessary is usually applied, the excess being blown out the exhaust and wasted. Moreover, due to negligence on the part of the operator the machine frequently operates for considerable periods of time without adequate lubrication, thereby causing excessive wear, power and production losses. Not infrequently the piston and cylinder are scored when operating under such conditions.

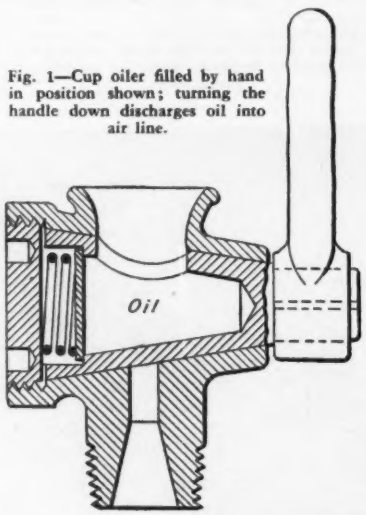


Fig. 1—Cup oiler filled by hand in position shown; turning the handle down discharges oil into air line.

Hand oiling may be improved to a certain extent by using the cup oiler shown in Fig. 1. This oiler is connected by means of a T-fitting in the air line near the machine. When the handle is turned vertically upward as shown, it can be filled with oil. Turning the handle down empties the oil charge into the air line, whence it is carried into the machine by the air stream. The chamber contains just sufficient oil for one charge, thus insuring a measured quantity of oil being introduced each time.

Impulse Oiler—The impulse oiler is built integral with such machines as paving breakers, sheeting drivers, spike pullers and drivers and other of the heavier machines. While these oilers of different manufacturers vary in details of design and construction, they all operate with a pulsating or pumping action similar to that of a heart. Referring to

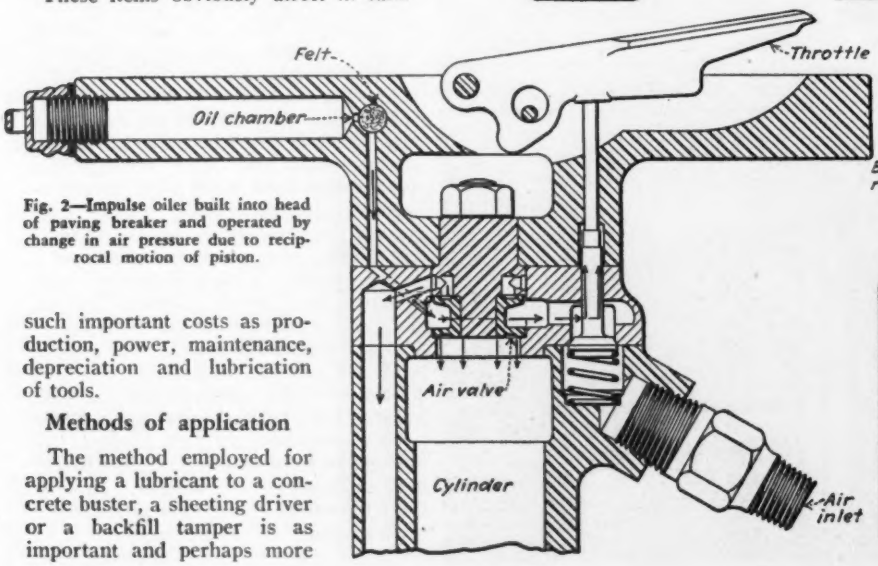


Fig. 2—Impulse oiler built into head of paving breaker and operated by change in air pressure due to reciprocal motion of piston.

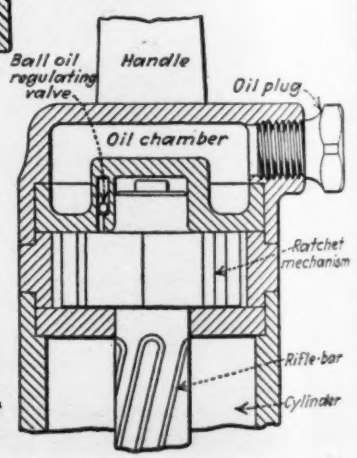


Fig. 3—Impulse oiler built in backhead of sinker-type rock drill and having ball valve regulator.

Fig. 2, the air within the cylinder is subject to a rapid fluctuation in pressure, due to the reciprocating motion of the piston. As the pressure builds up in the cylinder, some air enters through the small drilled passages to the chamber and collects in the space not occupied by the oil. When the pressure drops as the piston moves downward, a small quantity of oil is forced out of the chamber through the small passages into the cylinder by the higher air pressure still remaining above the oil in the chamber. Thus the rapid fluctuation of pressure causes a constant and minute oil flow, which is carried into the cylinder and distributed over the rubbing surfaces by the air. The cylinder of felt shown serves to regulate the oil feed, also acting as an oil filter, preventing any dirt that may have gotten into the oil chamber from entering the cylinder of the tool.

An impulse oiler built in the backhead of a sinker type of rock drill is shown by Fig. 3. A small ball valve serves to regulate the rate of oil feed in this oiler. Illustrated in Fig. 4 is an impulse oiler located in the handle of a demolition tool. As shown, a small oil-regulating plug containing an orifice governs the rate of oil feed. For oils of various viscosities the manufacturer furnishes plugs with different size orifices; the higher the viscosity of the oil the larger the orifice.

The impulse oiler is a great improvement over hand oiling, and it operates very satisfactorily and efficiently provided the chamber is kept clean and the small oil passages are not permitted to clog with dirt.

Air-Line Oiler—The air-line oiler is the latest and by far the most efficient and satisfactory device yet devised for supplying lubrication to air tools. This type of oiler is wholly automatic, is simply constructed, operates in any position and requires practically no attention save a thorough flushing out occasionally and a daily filling.

The air-line oiler shown in Fig. 5 operates in a manner similar to that of a common spray paint gun. The small tube containing the oil nozzles splits the air stream vertically, creating a suction on the downstream side, thereby drawing oil from the chamber. The pressure in the line and oil chamber is equalized by the small vent tube. No oil loss occurs when the air is shut off, either ahead of or behind the oiler, as the pressure in the oil chamber is vented into the line from the upper part of the chamber. Oil feeds through the nozzles only while the air flows through the oiler. The rate of oil feed is controlled by changing the relative position of the oil orifices with respect to the direction of air flow. The maximum rate of feed occurs when the orifices are at right angles to the axis of the air line; and the minimum rate of feed is obtained when the orifices are parallel with the axis of the air line. The air-line oiler shown in Fig. 6 differs considerably in design and construction from the one just described, but it operates in a similar manner.

Air-line oilers should not be placed, if possible more than 15 ft. from the machine, and each machine should be provided with an individual oiler, as shown in Fig. 7. This, with the correct oil, will insure the oil reaching the machine in a finely atomized condition and will minimize the deteriorating effect of the oil on the inner rubber of the hose. Atomized oil carried by the air distributes quickly and uniformly to all parts of the machine with which the air comes into contact.

In most instances where air-line oilers have been adopted 20 to 50 per cent lower repair costs, greater efficiency and greater dependability have been realized.

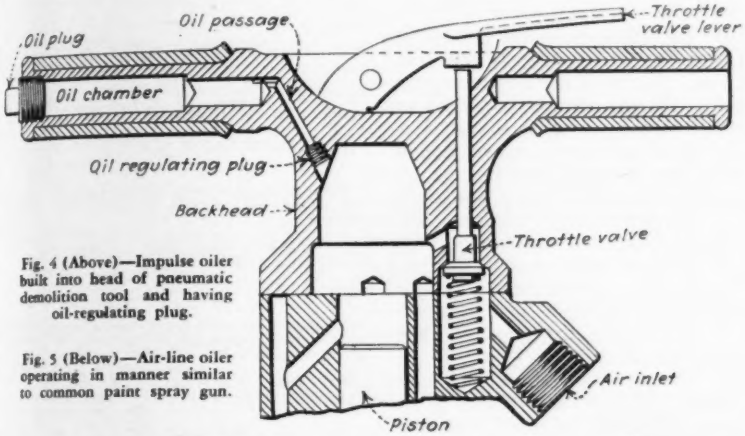
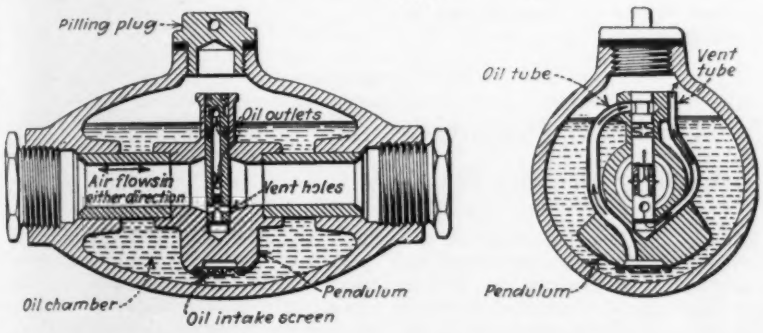


Fig. 4 (Above)—Impulse oiler built into head of pneumatic demolition tool and having oil-regulating plug.

Fig. 5 (Below)—Air-line oiler operating in manner similar to common paint spray gun.



Lubrication factors

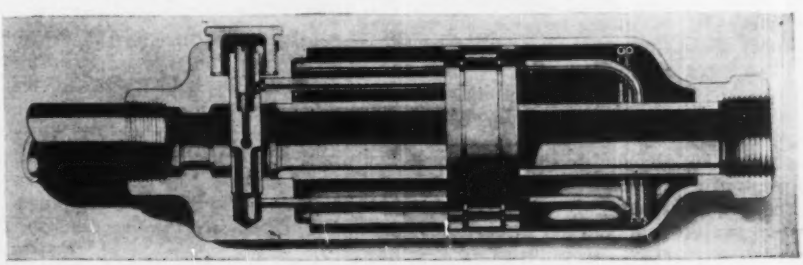
The important factors to be taken into consideration when selecting lubricants for air tools are: (1) water or moisture, (2) foreign matter, (3) temperature, (4) speed, (5) air pressure and (6) imposed loads.

Moisture is always present in pneumatic tool cylinders, except when reheated air is used. It may be present in relatively large amounts, or it may be very slight, depending upon the moisture content of the free air and the provisions made for draining it from the compressed-air pipe lines.

Moisture assisted by the rapid motion of the piston tends to wash off oil films formed on the various frictional surfaces. Thus an oil capable of resisting this washing effect is required. Such an oil is a good-quality mineral oil containing a certain percentage of fixed oil that is an animal or vegetable oil.

In general, air tools operate in locations where they are exposed to dirt, dust and weather conditions. As a result, foreign matter frequently enters the air compressor, and to a certain extent passes the compressor into the compressed-air pipe lines leading to the tools. This foreign matter is augmented by scale, rust and dirt in the air-pipe

Fig. 6—Variation in design and construction of air-line oiler with similar operating principle to the one shown in Fig. 5.



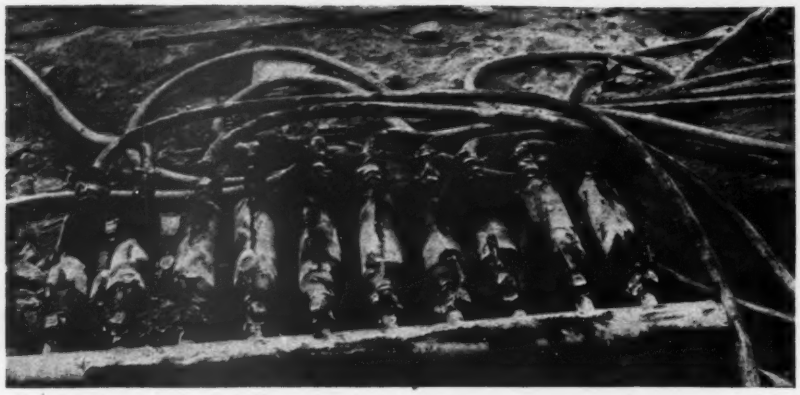


Fig. 7—A separate air-line oiler should be provided for each drill; oilers shown are for a battery of drills on New York subway excavation.

lines themselves. Unless effective air strainers are provided in the air line near the tool, these impurities pass into the cylinder of the tool, contaminating the oil and interfering with the formation of the essential oil films and thereby causing increased friction, wear and unreliable operation. The amount of dust contained in air that appears reasonably clear is seldom fully realized until analysis discloses its volume. The fact that much of this dust is microscopically fine and is often of silicious character increases its dangerous abrasive qualities.

As a rule, operating temperatures are not high because of the cooling effect produced by the expansion of the air within the cylinder. Furthermore, these tools are seldom operated continuously for long periods of time. In certain instances, however, operating temperatures may become quite high, as when the tools are operated in poorly ventilated places. On the contrary, they are sometimes operated in the open in very cold weather at infrequent intervals. Under these conditions operating temperatures may be very low.

Thus to meet such widely varying temperature conditions, the oil selected must possess the necessary body to form tenacious oil films at high temperatures, and at the same time not to be too heavy to spread freely and uniformly at very low temperatures.

The number of strokes per minute varies with the type of machine and the air pressure. In general, they strike from 1,000 to 2,400 blows per minute. The average rubbing velocity of the piston is usually about 1,000 ft. per minute. The maximum velocity may be two or three times this average.

The force of the blow struck is proportional to the square of the striking velocity. Hence it is most important that the piston move freely and easily in order to accomplish the maximum amount of work efficiently. A sluggishly moving piston not only strikes fewer blows per unit of time but also strikes less effective ones. It is therefore essential that the oil selected possess the minimum fluid frictional resistance and yet have the requisite adhesiveness to stick to the cylinder walls and other rubbing surfaces and form oil films, which are so necessary to prevent blow-by and metal-to-metal contact.

Air pressures are moderate, as a rule, rarely exceeding 100 lb. per sq.in. But air pressures are not necessarily a criterion as to the maximum air pressure in the cylinder, as most pistons are "air-cushioned" at the ends of the stroke, thereby increasing the pressure above that of the line.

The air pressure coupled with the turbulent effect produced by the air as it passes through the relatively small passages in entering and leaving the cylinder tends to disrupt the oil films. Hence the oil must be capable of forming films that will adhere to the metal surfaces under these adverse conditions.

The pressures existing between certain parts of these tools are often high, even under normal working conditions. This is especially true of the chuck-end parts, as the tool is frequently used as a crowbar.

The lubricant must be capable of creeping into the small clearance spaces of these parts and at the same time resisting the squeezing action of the heavy pressures.

Lubricants recommended

From the foregoing discussion it may be thought that it would be necessary to select several different lubricants of widely varying characteristics. Such is not the case, however, as experience has proven that it is possible to lubricate these tools correctly with two oils of the specifications given in the table below.

RECOMMENDED LUBRICANTS FOR AIR TOOLS

For light tools such as backfill tampers, bolt drivers, clay spades, etc., use a heavy-bodied, pure mineral machine oil.

Pour Deg. F.	Flash Deg. F.	Fire Deg. F.	Sp. Gr.	A.S.T.M. Viscosity at 100°	130°	210°
−10	.070	420	.920	234	112	45

For heavier tools such as paving breakers, spike drivers and pullers, sheeting drivers, etc., use a compounded engine oil.

Pour Deg. F.	Flash Deg. F.	Fire Deg. F.	Sp. Gr.	A.S.T.M. Viscosity at 100°	130°	210°	Per Cent Compound*
10	350	385	.930	535	250	66	10

*The compounding should be pure-blown rape seed oil.

Paratyphoid Pollution in London's Water Supply

EFFECTIVE precautionary measures overcame the danger of an outbreak of paratyphoid in the East End of London, England, in the early months of 1931, when a serious paratyphoid contamination was discovered in one of the tributaries of the River Lee. Sterilization was employed on the polluted tributary and on the effluent of the slow sand filtration plant supplying that portion of London. The nature of the pollution, the measures taken to overcome it and the satisfactory outcome were described by Sir Alexander Houston, director of water examination of the Metropolitan Water Board of London, in his 26th annual report.

A serious epidemic of paratyphoid due to infected milk occurred at the small town of Epping. The sewage from this town is treated by land irrigation, the effluent flowing into Collins Brook. Collins Brook is a tributary of the River Lee, from which the bulk of the water supply of London's East End is taken. Examination of the effluent of Epping's sewage farm revealed the fact that Collins Brook was being polluted to the extent of 33,000,000 paratyphoid bacilli per day. Samples of the stream continued to show the presence of these bacteria until the end of 1931. Sterilization of both the contaminated tributary and the filtered water has been continued into 1932.

Treatment of this water supply consists of storage in Walthamstow reservoir for 29 days and passage through slow sand filters at the rate of 2 Imperial gal. per square foot per hour. Samples taken from the reservoirs after storage gave negative results when examined for paratyphoid bacilli in 500-c.c. amounts. Samples of the Epping effluent kept in the laboratory at 10 deg. C. showed that the paratyphoid bacilli died in about three weeks.

During the danger period a few cases of typhoid and paratyphoid occurred in the area served by the Metropolitan Water Board of London, but a careful comparison of the number of cases occurring in the year 1930 with those for 1931 showed that there was no increase in the incidence of these diseases in the areas served.

Effect of Cement Composition on Mortar Strength

High tricalcium silicate gives early strength in standard sand mortars and high dicalcium silicate gives increase in strength after first month

By Hubert Woods, Howard R. Starke and Harold H. Steinour
Riverside Cement Co., Riverside, Calif.

THIS ARTICLE is a summary of the results arrived at in the second phase of the studies on the composition of portland cement, conducted by the research department of the Riverside Cement Co., of California. A summary of the first phase of the study, which was a determination of the heat evolution of cements, was published in the issue of Oct. 6, p. 404.
—EDITOR.

THIS ARTICLE deals with the compressive and tensile strengths of 1:3 standard Ottawa sand mortars made from cements whose clinker compositions are given in Table I of the preceding article in the Oct. 6 issue, p. 404. The test methods employed were those designated by the American Society for Testing Materials as standard method C77-30 and tentative standard method C 9-16 T, except in the following particulars:

1. A constant ratio of water to cement of four-tenths by weight was used.
2. The compressive specimens were molded in three layers about 1¼ in. thick.
3. The compression specimens were capped with a mixture of one part of plaster of Paris and three parts of cement just prior to their removal from the molds.

In addition to the requirements of C 9-16 T, the following points were observed:

1. The pressure applied to each layer of mortar was that produced by the free fall of the tamper operating on a stroke of approximately 2 in.
2. Each layer of mortar was tamped until moisture appeared at the surface.

The finenesses of the cements, expressed as specific surface, were determined by means of a sedimentation device developed at this laboratory.[1]

Experimental data

The tensile and compressive-mortar strengths at the ages of 3, 7, 28, 90 and 180 days for eleven portland cements of compositions variable only in the four major constituents are shown in Table I. This table also presents the cement fineness, the clinker analysis and the calculated amounts of the compounds in the clinker. The latter calculations were made according to the method of Bogue.[2]

Due to the method of preparation all of these cements gave less residue on the 200-mesh screen than is generally the case with commercial cements of the same specific surface. The surface values correspond to good commercial practice.

Each strength value reported was obtained by loading three test specimens to failure and calculating the average unit load at failure. In this investigation the maximum strength variation of every one of the three specimens was within 15 per cent of their average value.

The specific surface determinations are considered to be reproducible to about ± 1.5 per cent. A careful examination of the data shows that specific surface variation has had no obviously pronounced effects, which indicates that this variation is of no greater order of magnitude than others occurring in the investigation.

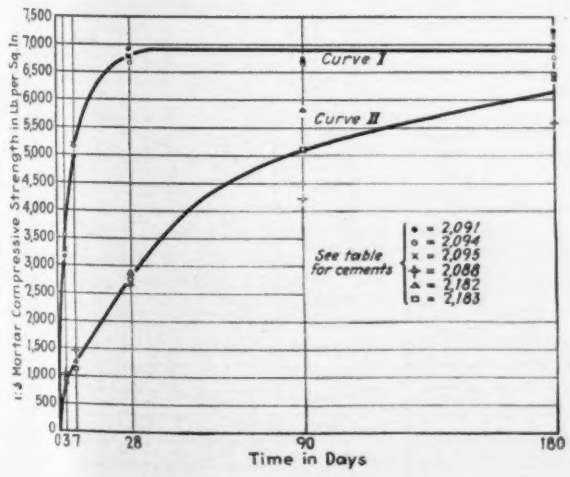
In recognition of the magnitude of the probable error in this work, the findings are presented as general effects and not as precise values capable of use in predicting the strength value of a cement. However, the conclusions are of value in the general relative design or rating of cements.

The cements used in this investigation were prepared in the laboratory. The use of laboratory data directly in commercial practice requires caution. A number of variables, other than the proportion of the major oxides, enter into the manufacture of portland cement. These may have a pronounced influence upon strength development. A knowledge of these variables and of their effects is required in addition to a knowledge of the major effects of composition before the question of strength development of portland cement can be completely understood.

Analysis of data

An examination of Table I reveals a most striking range in mortar strength at three days and a gradual narrowing of the range with time. A partial presentation of these data is made in Fig. 1. The three cements having the highest three-day strengths and the three cements having the lowest three-day strengths are represented. These serve to show the range in strength. The curves have been added to assist in a general visualization of the data and to serve as type curves for the high- and low-early-strength cements.

Examination of the calculated clinker constitution for these cements indicates that the distinction to be made between the type of curve I and the type of curve II is in the tricalcium silicate and dicalcium silicate content. The other two compounds indicate no governing influence, although the tendency of the data shown on the plots to become relatively more divergent at the later ages might be an indication of the influence of these compounds at those



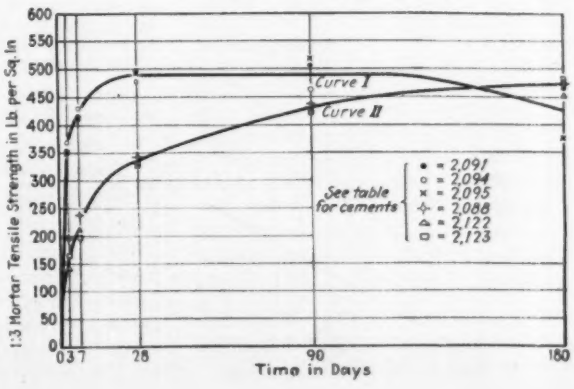


Fig. 1 — Characteristic curves, showing range in mortar strengths at three days for high- and low-early-strength cements and gradual narrowing of the range with age.

ages. This divergence, however, is not great enough to destroy the comparative distinction made on the basis of the tricalcium silicate and dicalcium silicate contents.

A study of the calculated clinker-compound data in Table I shows that the sum of the contents of tricalcium silicate and dicalcium silicate in each cement varies by about 10 per cent over the entire range of composition. For eight of the eleven cements this variation is only about 5 per cent. In view of this relationship it will be seen that high tricalcium silicate content is practically synonymous with low dicalcium silicate content, and vice versa.

The high rate of strength increase during the first month for the high-tricalcium-silicate cements is in contrast with the comparatively low rate of the high-dicalcium-silicate cements. The rather sudden decrease in rate of the former after the first month and the continued rate of the latter furnishes another most interesting contrast. After the first month the high-dicalcium-silicate cements have a higher rate than do the high-tricalcium-silicate cements. As a consequence, the early-strength advantage of the high-tricalcium-silicate cements tends to be overcome gradually and by six months is largely lost. Further evidence of the predominating influence of tricalcium silicate is seen in the close agreement between the plotted points and the straight line of positive slope in the curves of Fig. 2, where strengths are shown as a function of the tricalcium silicate content of the clinker.

Any reasonable extrapolation of the 3-day tensile, and the 3-, 7- and 28-day compressive-strength curves to zero per cent of tricalcium silicate indicates that the other compounds can have only a minor effect at these respective ages.

Examination of the 90-day compressive, the 7-day tensile, or any of those curves later than these respective ages gives indication of the strength influ-

TABLE I — 1:3 OTTAWA SAND MORTAR STRENGTHS IN POUNDS PER SQUARE INCH

Cement No.	Fineness as Specific Per Cent Through 200 Mesh	Fineness Surface Sq.Cm. pr Gram	Tensile Strength 3 Days	Tensile Strength 7 Days	Tensile Strength 28 Days	Tensile Strength 3 Months	Tensile Strength 6 Months	Compressive Strength 3 Days	Compressive Strength 7 Days	Compressive Strength 28 Days	Compressive Strength 3 Months	Compressive Strength 6 Months
2091	99.9	1,670	353	415	497	505	397	3,115	4,965	6,931	6,753	7,260
2088	99.8	1,480	195	238	343	437	473	1,022	1,464	2,657	4,231	5,590
2089	99.9	1,580	353	367	432	478	520	2,396	3,173	4,533	6,895	7,290
2094	99.9	1,560	368	430	477	462	463	3,533	5,145	6,659	6,643	6,780
2085	99.9	1,530	315	372	390	462	422	2,883	4,077	5,230	5,431	6,946
2095	99.9	1,630	350	413	493	517	377	3,268	5,150	6,786	6,706	7,027
2096	99.9	1,500	285	332	433	450	512	2,305	3,365	4,967	6,347	7,600
2122	99.9	1,390	143	212	325	428	452	892	1,254	2,881	5,831	6,405
2123	99.5	1,450	165	197	328	422	482	910	1,126	2,742	5,097	6,482
2124	99.8	1,570	198	220	300	388	485	1,425	1,665	3,368	4,753	6,570
2125	99.9	1,620	245	305	365	447	467	1,766	2,590	4,367	5,697	6,757

CLINKER CONSTITUTION

Cement No.	Clinker Analysis SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO Total	CaO Uncombined	Calc. Per Cent Clinker Compounds 4 CaO Al_2O_3 Fe_2O_3	3CaO. Al_2O_3	2CaO. SiO_2	3CaO. SiO_2	Per Cent Gypsum in Cement as Gypsum	as SO_3
2091	21.94	5.57	2.68	2.44	67.71	0.00	8.2	10.2	11.8	67.7	3.23	1.5
2088	24.60	5.85	2.80	2.40	64.18	0.00	8.5	10.8	47.1	31.0	3.23	1.5
2089	21.96	4.65	6.06	2.32	64.07	0.00	18.4	2.1	22.2	54.0	3.23	1.5
2094	20.93	4.64	5.74	2.08	66.26	0.00	17.5	2.6	6.2	71.3	3.23	1.5
2085	22.32	6.17	2.85	2.43	66.47	0.00	8.7	11.5	22.2	55.5	3.23	1.5
2095	21.34	6.07	2.93	2.56	67.03	0.03	8.9	11.1	11.6	65.7	3.23	1.5
2096	25.04	3.86	2.11	2.36	66.57	0.00	6.4	6.7	32.7	51.8	3.23	1.5
2122	27.68	3.76	1.98	2.48	64.97	0.00	6.0	6.6	59.7	26.0	3.23	1.5
2133	25.96	3.48	5.06	2.32	63.15	0.00	15.4	0.7	52.4	29.2	3.23	1.5
2124	23.54	4.83	7.21	2.24	62.03	0.00	21.9	0.6	44.2	30.9	3.23	1.5
2125	22.48	5.00	7.46	2.24	62.72	0.00	22.7	0.6	34.1	40.2	3.23	1.5

ence of those compounds other than tricalcium silicate. It is seen that in the interval between these ages and the earlier ones at which tests were made the cements low in tricalcium silicate have gained more strength than those high in this compound. From this it follows that one or more of the other compounds are producing strength at a greater rate than is tricalcium silicate.

The conclusions drawn from Fig. 1 indicate that the strength increase during the later ages, from 28 days to six months in this case, is largely attributable to dicalcium silicate. By examination of Fig. 3, which shows the gain in strength during the period from 28 days to six months plotted against the percentage of dicalcium silicate, tricalcium aluminate, and tetracalcium alumino ferrite, it will be seen that these data are in accord with those conclusions. The influence of dicalcium silicate upon strength development during this period is quite pronounced.

The absence of any correlation between strength development during this period and the amount of tricalcium aluminate or tetracalcium aluminoferrite, and the very small strength development shown during this period for those cements low in dicalcium silicate and comparatively high in tricalcium aluminate or in tetracalcium aluminoferrite indicates that only minor strength influences can be attributable to the latter two compounds.

The negative values shown in Fig. 3 may be attributed to the general tendency for cement high in tricalcium silicate to show retrogression in tensile strength after six months' immersion in water (Fig. 1). There is considerable question as to whether this retrogression observed on small test specimens would be observed under the different conditions of actual use.

The slopes of the curves in Fig. 2 may now be examined more closely. Since the compounds other than silicates have been indicated to have but a minor effect, and since the sum of the silicates in each cement is practically constant, it follows that an approach of the curves to the horizontal may thus be interpreted as indicating an approach of the two silicates to equivalent specific strength value. Such an approach is shown by the curves.

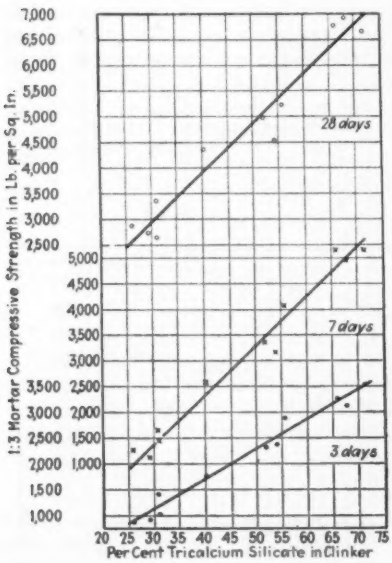
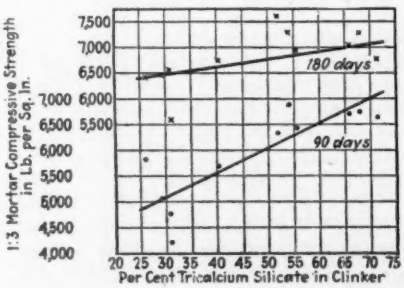
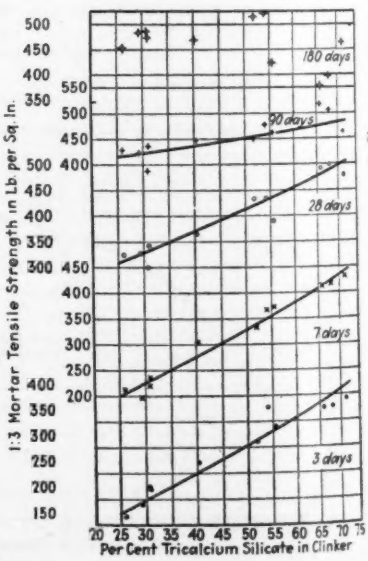


Fig. 2—Curves showing at various ages predominating influence of tricalcium silicate on mortar strength and its decreasing effect with age.





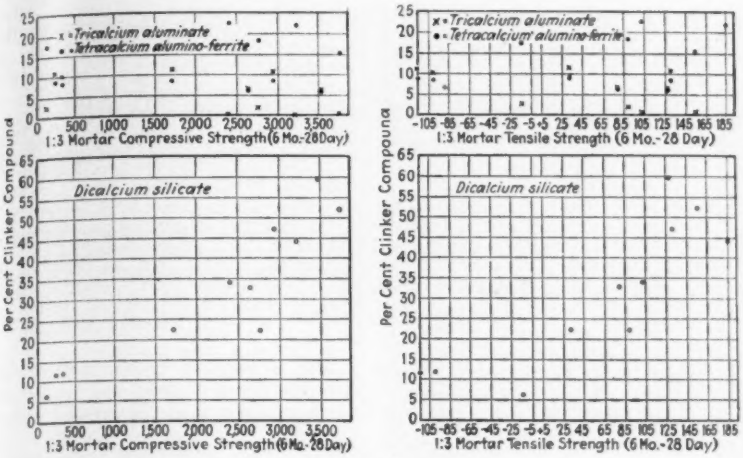

x = Tricalcium aluminate
• = Tetracalcium alumino-ferrite
Per Cent Clinker Compound
1:3 Mortar Compressive Strength (6 Mo.-28 Day)
Dicalcium silicate
1:3 Mortar Tensile Strength (6 Mo.-28 Day)

Fig. 3—Data showing influence of dicalcium silicate, tricalcium aluminate and tetracalcium alumino-ferrite on strength increase between 28 days and 6 months.

The conclusions drawn with respect to the preponderating influence on strength development of tricalcium silicate during early periods and that of dicalcium silicate during later periods are in agreement with the findings of others.[3]

The tensile and compressive strengths of 1:3 standard Ottawa sand mortar were determined at 3, 7, 28, 90 and 180 days for a number of portland cements of varied composition and normal fineness. The following conclusions are indicated, and they apply to the conditions under which the data were obtained:

1. Changes of a few per cent in the oxide proportion of portland cement may have large influences on the magnitudes and rates of strength development of the cement at ages up to six months.

2. The early strength of portland cement is largely attributable to tricalcium silicate. Cements high in tricalcium silicate generally have a high-early strength and they are found to develop a large proportion of their six-month strength in one month.

3. The increase in strength of portland cement after one month is largely attributable to dicalcium silicate. Cements high in dicalcium silicate generally show an initially less rapid but more prolonged strength development than do cements high in tricalcium silicate.

4. In the case of tensile strength the influence of compounds other than tricalcium silicate appears to be manifested at ages earlier than one month.

5. At six months the strengths of cements high in tricalcium silicate and of cements high in dicalcium silicate are of the same order of magnitude.

References

[1]U. S. patent No. 1,838,628, "Apparatus for Measuring the Fineness of Finely Divided Materials."

[2]Bogue, "Calculation of Compounds in Portland Cements," *Industrial and Engineering Chemistry*, Analytical Edition 1, p. 192 (1929).

[3]Bogue, "The Nature of the Setting and Hardening Processes in Portland Cement." *Rock Products*, May, 1928, to September, 1928, inclusive.

The Cement-Macadam Road Gets a New Trial

Grouted stone surface 18 ft. wide and 6 in. thick constructed on Morris County highway in New Jersey at low cost

Introduction

A LITTLE more than 25 years ago a number of New England cities began putting down stretches of pavement constructed by grouting and rolling a layer of coarse crushed stone. This construction was patented and called after its inventor "Hassam pavement." From 1905-1906 to 1923 considerable yardages of Hassam pavement (Fig. 1) were laid in at least a score of Connecticut and Massachusetts cities and elsewhere. As late at 1921 the wearing course of the street-railway pavement (a yardage equivalent to 40 miles of 16-ft. pavement) in Detroit, Mich., was constructed of grouted stone compacted by rolling. (*ENR*, Sept. 29, 1921). About the latest of the Hassam pavements were constructed in 1923 in Bridgeport, Conn., and Malden, Mass.

It is nearly a decade then since grouted stone pavement has been a frequent type of construction in the United States. In this same period and particularly in the last five years the cement-penetration or grouted stone pavement has become current construction in continental Europe, in Great Britain and in Australia. Some information on this foreign practice has been published in *Engineering News-Record* of Oct. 23, 1930, and Feb. 25 and July 28, 1932.

In general, two types of construction are employed abroad: one the regular process of penetrating crushed stone with a thin grout, and one a process of sandwiching a 1-in. layer of mortar between two 2-in. layers of stone and rolling the slab until the mortar penetrates the stone and flushes to the surface. The last type of construction is favored in Great Britain and is commonly defined as cement-bound construction. In some continental practice dry cement has been spread on the stone and flushed into the voids by water. The European roads of the cement-penetration and cement-bound types are generally thinner (about 4 in.) than were the old Hassam pavements in America or are the present Australian roads; these run 7 to 8 in. thick when compacted.

Two thoughts have governed past practice in penetrating stone with cement: one has been to produce a concrete pavement comparable with mixed concrete, and the other has been to produce a cement-bound macadam road surfacing. The Hassam process had distinctly in mind the production of concrete *in situ*. In much of the present continental European construction the objective sought is not a cemented macadam but a pseudo-concrete—a product cheaper than machine-mixed and placed concrete, but a true concrete. In much of the Australian roadwork a positive attempt has been made to simulate concrete pavement, even to the extent of coating the surface with mortar and belt-finishing the mortar to a level contour.

With the background that has been briefly outlined, practical experimentation has again been begun in the United States with grout-penetrated stone road surfacing. It appears that experimental roads will be straight cement-penetration macadam. The stone will be the strength and wearing element, and the cement the binding element to hold the stone rigidly in place. In brief, the construction is cement macadam and not pseudo-concrete; it is a secondary road surfacing. Mr. Spargo, chairman of the road committee in Morris County,

Fig. 1—Grouted stone pavement 26 years old built under Hassam patents in Norwich, Conn. This pavement shows cracks that have been filled with bituminous material, but generally it is in the remarkably good condition indicated.

describes in the following article the first stretch recently completed at Myersville, Morris County, N. J.

* * *

New Morris County Road

By William C. Spargo

Chairman, Highway Committee, Morris County Board of Chosen Freeholders, Morristown, N. J.

AFTER giving careful consideration to the possibilities of cement-penetration macadam, based on observation of such pavements in use for the past quarter of a century, and to the apparent possibility of low cost for construction and subsequent maintenance upkeep, it was decided to introduce a 1,000-sq.yd. test section on a bituminous-penetration macadam road then under construction between Myersville and Chatham in Morris County, New Jersey.

Placing stone

The experimental road is 500 ft. long, 18 ft. wide and 6 in. thick, with a 4-in. crown, corresponding in cross-section to the adjoining bituminous-macadam pavement. The original road surfacing was a thin, worn-out water-bound macadam, which was scarified and reshaped for the new surface. The shoulders are 4 ft. wide and of well-compacted earth and stone. The roadbed is well drained.

Trap rock from a near-by commercial quarry, 1½-in. size (graded from 1¼ to 2¼ in.) was spread one-half roadway width at a time by tailgate end-dumping from trucks carrying about 9 tons, as shown in Fig. 2. Prior to grouting, the stone course was given one light rolling with a three-wheel 10-ton roller. Only sufficient compaction to support grout trucks without displacement of the stone was desired.

In view of the short length of the project it was decided to omit expansion joints. However, to control cracking, dummy joints were formed by fastening 1x2-in. wood strips though the center and transversely at 50-ft. intervals, as shown in Fig. 3. The transverse strips were installed as stone spreading progressed.

Mortar quantities were based upon an estimated 40 per cent of voids in the stone after compaction. From preliminary investigations it was decided to use 1:2 grout proportions with ordinary concrete sand (passing ¼-in. sieve) and 8 gal. of water per sack of cement exclusive of free moisture in the sand, which was estimated to be about 2 per cent. On this basis the water ratio was 8½ gal. per sack of cement. A grout mix of 1:1½ with 5½ gal. of water per sack of cement was used on the last 88 ft. to determine any difference in working qualities and strength caused by a drier and leaner mixture.

Transit-mix trucks of 4-cu.yd. capacity, carrying 3 cu.yd. of grout, were used. The actual batch per truck included 30 sacks of cement, 6,000 lb. of sand and 240 gal. of water, not including estimated moisture content of 2 per cent in the sand. About 100 gal. of water was stored in the reserve tank on the trucks, to be added when the job were reached. The batch with the remainder of the water was mixed intermittently during transit, and a final mixing with all the water was given at the job. The one-way haul from the plant of the transit-mix company that furnished the grout was 11½ miles; the round trip took about two hours. A truck-mixer load weighed about 10,800 lb.

The transit-mix trucks were backed onto the crushed stone and discharged through a chute that was swung to spread the grout across the road as the truck pulled ahead (Fig. 4). One batch covered about 25 ft. of road. The discharge of grout tended to float the stone and required care to prevent displacement. A light rolling followed the grouting in order to facilitate penetration, but the final rolling was given about half an hour later. The mortar flushed to the surface was broomed into the voids or from the surface, as the objective was to leave the surface stone exposed and create a stone mosaic wearing and traction surface.

The force handling the grout consisted of one man on the chute, four or five with brooms back of the chute and two with brooms and stone forks after the final rolling.

Pre-wet hay was spread over the finished surface for curing. The hay was removed, and the pavement was opened to traffic at the end of four days.

The cost of 500 ft. (1,000 sq.yd.) of cement-penetrated macadam was as follows:

Cost per square yard for stone course complete in place	42.6c.
Cost of cement-grout penetration	56.5c.
Total	99.1c.

The work was performed by the

Fig. 2—Stone was spread half-width at a time from the tail of a truck carrying nine tons for the new Morris County, N. J., road.

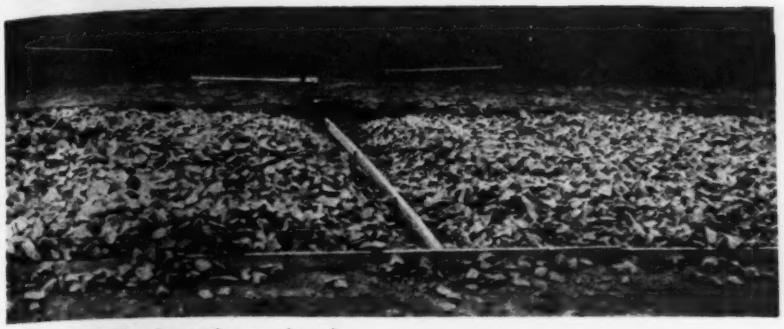


Fig. 3—Wood strips resting on the subgrade and buried by stone form dummy joints; string shows top surface of loose stone.

county construction forces, who used their own equipment. Cement grout was supplied by a commercial truck mixing plant. Construction was under the direction of Winfield Hopkins, county engineer, with Raymond E. Shorter, assistant supervisor of roads, in charge.

Core-drill results

Cores 6 in. in diameter (Fig. 5) taken from the road indicate that the average thickness of the pavement is 5¼ in., or ¾ in. short of the 6-in. depth originally planned. The core depths indicate that an allowance of about 20 per cent must be made for compaction and pressing of the stone into the subgrade under the action of the roller. It was apparent that labor and equipment cost savings to the extent of 10 per cent could be made on projects similar to that constructed. However, the additional cost for materials, equipment and labor, in order to construct the full 6-in. depth, would amount to 13c. per square yard. Such adjustments in cost of this particular section would give a final result of $1.03 per square yard in actual construction cost.

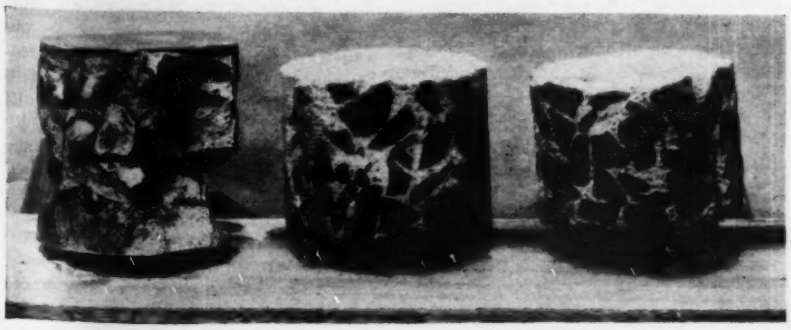
Successful crack control

It is of interest to note that the dummy-joint method for crack control functioned as anticipated. A crack survey made four weeks after placing the pavement showed that the cracks had occurred transversely and longitudinally directly over the 1x2-in. strips. The variation of these cracks from a straight line is not more than 1 in. either way, and they apparently will serve admirably the purpose for which they are intended.

Tests of the cores by the New Jersey state highway department laboratory show the results given in the accompanying table.

Fig. 4 — Truck mixers carrying 3-cu.yd. batches supplied 1:2 grout for the penetration work; grout was proportioned at commercial central proportioning plant 11½ miles from job.

Fig. 5—Cores drilled on twelfth day after placing pavement. Core at left is 1:1½ grout, with breaking load at 29 days 5,555 lb. per sq.in.; core in center is 1:1½ grout, breaking load at 33 days 4,540 lb.; core on right is 1:2 grout, breaking load at 33 days 3,666 lb.



CORE TESTS OF CEMENT-PENETRATED STONE SURFACING

Sta.	Grout Mix	Age at Test, Days	Actual Load, Lb. Per Sq. In.	*Corrected Strength $H = 2D$, Lb. Per Sq. In.
2 — 00	1-2	33	3,666	2,980
4+50 ft.	1-1½	29	4,429	3,810
4+62.5 ft.	1-1½	29	5,555	4,670
4+75.5 ft.	1-1½	33	4,540	3,730

* A.S.T.M. C42-27 for $H = 2D$

Observations

As a result of the experience obtained on this section and also from a study of Hassam pavement constructed prior to ten years ago it is felt that the following general practice will give satisfactory resutls:

1. Base-course stone should be as nearly one size as possible within the limits of 1¼ to 2½ in.
2. Concrete-grade sand passing a ¼-in. sieve is satisfactory.
3. A 1:2 mortar mix based on dry loose materials with a water ratio of not more than 8 gal. per sack of cement, exclusive of average moisture content in sand, is satisfactory.
4. An allowance of 20 per cent should be made for compaction and for working of the stone into the subgrade under the roller.
5. Sufficient rolling prior to grouting should be given to compact the stone but not interfere with grout penetration.
6. Rolling immediately after the application of the grout should be only sufficient to assist penetration.
7. The final rolling should be done about 20 min. after placing the grout.
8. All surplus mortar should be removed from the surface (the amount of surplus mortar can be controlled by initial application and amount of final rolling performed).
9. A longitudinal joint should be provided, and it appears that a dummy joint with resulting crack, as described above, will be the most satisfactory low-cost method. A spacing of not less than 100 ft. for transverse contraction joints should prove satisfactory.
10. It is desirable that cores be taken as a check on depth and also proper grout penetration.
11. A 48-hour wet curing will be satisfactory.
12. The pavemnet may be opened under ordinary conditions for light traffic in four days and for all types of traffic in six days.

Eight Years' Operation of Passaic Valley Sewer

Serving 22 communities, the system was put into operation in 1924—Oxygen tests of Passaic River show that pollution has been greatly relieved—Costs of operation outlined

By J. Ralph Van Duyne
Chief Engineer, Passaic Valley Sewerage Commissioners, Newark, N. J.

EIGHT YEARS AGO the Passaic Valley sewer system was put into operation. The sewage of 22 communities in northern New Jersey, instead of being discharged into the Passaic River, is now intercepted by the sewer, screened and settled, and discharged into deep water in New York Bay. In consequence, a vast improvement has been effected in the condition of the river, formerly one of the most heavily polluted streams in the United States. This article reports on the results obtained and the costs involved in operating the system up to the present time. —EDITOR.

THE PASSAIC VALLEY sewerage system was constructed to intercept and dispose of the polluting wastes from a district in northern New Jersey about 80 square miles in area, embracing 22 separate municipalities and containing a present population of more than 1,000,000 inhabitants. This area extends from Paterson on the north to Newark on the south and from the Orange mountains on the west to the watershed divide between the Passaic and Hackensack valleys on the east.

The seriously polluted condition of the Passaic River was realized as far back as 1896. In that year the state legislature passed an act creating a commission to study the problem and to recommend a general system of sewage disposal to accomplish the much needed relief. Sixteen years, however, elapsed before actual construction of the Passaic Valley System was started in the spring of 1912 and it was not until August, 1924, that this $21,000,000 project was completed and put into operation.

The system consists of a main intercepting sewer 22 miles long varying from 3 ft. 9 in. to 12 ft. 6 in. in diameter, 14 miles of branch intercepting sewers from 1 ft. to 5 ft. in diameter, 9 river crossings ranging 1 ft. 4 in. to 4 ft. in diameter to connect the municipalities on the east side of the river with the main intercepting sewer on the west side, three pumping stations, sedimentation basins and a 5-mile pressure tunnel 12 ft. in diameter leading from the sedimentation basins to the dispersion system in the middle of New York Bay, 2 miles north of the Statue of Liberty.

The executive body created by the laws of New Jersey to construct, maintain and operate the system is known as the Passaic Valley Sewerage Commissioners. It is composed of five members appointed from the district by the governor of the state for terms of five years each. The term of one commissioner expires each year, and he is either re-appointed or a successor to him is named. The laws further provide that the construction of the sewer system should be paid for by the participating municipalities in direct proportion to their ratables for the year 1907, and that after the construction of the system the maintenance and operation should be paid for annually on the basis of use. This, of course, entails the necessity of measuring the flows discharged to the system by each of the 22 municipalities and represents a considerable item in the operating costs.

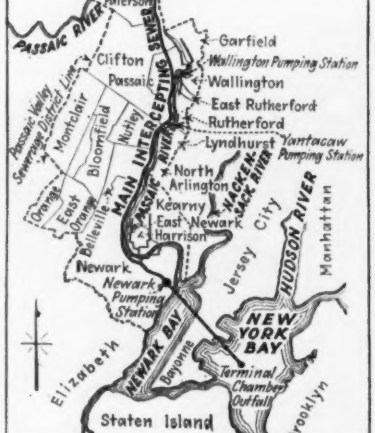


Fig. 1—Map of the Passaic Valley sewer which serves 22 communities in Northern New Jersey.

The design of the system is based on the return of all flows from combined sewers to the river during storm periods. This is accomplished by the insertion of automatically controlled valves and tide gates in all connection chambers where combined sewers are intercepted. The controlled valves are actuated by floats that rise as the level of flow in a combined sewer rises and cause the gates to the intercepting sewer to close, whereupon the unbalanced pressure against the tide gates causes the latter to open and the flow to discharge into the river. When the storm ceases and the flow in the combined sewer returns to normal, the floats lower and permit the valves to the interceptor to open again, and the tide gates automatically close.

COST OF PASSAIC VALLEY SEWER SYSTEM

Main intercepting sewer 22 miles, 3'9" to 12'6" diameter.....	$7,000,000
Branch sewers 14 miles, 1'6" to 5'4" diameter.....	1,500,000
Outfall tunnel 5 miles, 11'0" to 12'0" diameter.....	5,500,000
Pumping stations.....	500,000
Total.....	$14,500,000

There are more than 1,000 miles of municipal sanitary sewers tributary to the Passaic Valley intercepting sewer. In storm times, due partly to infiltration into the sanitary sewers from leaky joints and partly to the fact that in residential sections roof drainage is often connected to sanitary sewers, the flow often doubles in volume, and during protracted heavy storms it amounts to three times the normal dry-weather flow.

The organization employed by the commission consists of an accounting and clerical department under the direct supervision of the secretary and treasurer of the commission and a maintenance and operating department under the direct charge of the chief engineer. The maintenance and operating department has charge of the actual physical operation of the system, including the measurement of all sewage flows and river control. For convenience it will be described under the following heads: main office, pumping stations, sedimentation basins, maintenance of line, meter department and chemical department and river control.

Main Office—The duties of the main office are chiefly routine, consisting of planimetering charts and figuring the daily sewage flows from the municipalities tributary to the system, preparing payrolls and contracts, purchasing supplies, studying and designing improvements for the system and preparing the annual budget.

Pumping Stations—Maintaining and operating the three pumping stations constitutes a most important part in the functioning of the system. The Wallington pumping station, located farthest upstream, receives the flow of all the low-lying territory on the east bank of the Passaic River in the Borough of Wallington, Borough of East Rutherford, a part of the Borough of Rutherford, the Dundee section of Passaic and the city of Garfield. This station is equipped with three motor-driven centrifugal pumps, one 25-m.g.d. unit and two 15-m.g.d. units—which lift the sewage 18 ft. to the hydraulic gradient of the main intercepting sewer. Power for the operation of the station is purchased. Two of the three pumping units are equipped with emergency gasoline engines. During the eight years of operation the emergency equipment has been needed on an average of

once each year, usually because of interruption to service caused by electric storms. The most serious interruption, however, occurred in July, 1925, as the result of trouble with the electric cable crossing the Passaic River. The current was off for 14½ hours. The operating crew at this station consists of two men on each eight-hour shift, one operator and one helper.

The Yantacaw pumping station receives the flow from the remainder of the low-lying area on the east side of the Passaic River, south of the area tributary to the Wallington pumping station, and includes a portion of the towns of Lyndhurst and Rutherford.

This station is equipped with three 6.5-m.g.d. electrically operated centrifugal pumps that lift the sewage 25 ft. to the hydraulic gradient of the main intercepting sewer. Power for the operation of this station is also purchased. An emergency gasoline driven generator is installed, capable of operating the full capacity of the station. This generator has been needed a number of times during the eight years of operation when electrical storms have temporarily interrupted the utility power. The operating crew at this station also consists of two men on each eight-hour shift, one operator and one helper.

Newark Bay pumping station receives the entire flow of the district and raises it about 37 ft. into the adjacent sedimentation basins, from which it flows by gravity through a 5-mile outfall pressure tunnel into the dispersion system in New York Bay. The sewage passes through a grit chamber, coarse screens and then to the suction sewer and the pumps. The station is equipped with four vertical steam-driven centrifugal pumps, each capable of handling 125 m.g.d. The pumps are driven by triple-expansion reciprocating condensing engines, directly connected to the pump impeller by 12-in. solid-steel shafts 40 ft. in length. The speed of the pumps is 100 r.p.m. Steam is furnished for the engines at 175 lb. pressure at throttle by nine 250-hp. hand-fired fire-tube boilers.

OPERATING COSTS OF PUMPING STATIONS

Year	Quantity Pumped, M. G	Cost of Operation: Wages	Power	Misc.	Total	Cost Per M. G Pumped
Wallington Pumping Station						
1924	689	$8,369	$2,564	$794	$11,727	$19.24
1925	2,464	23,334	6,581	1,936	31,851	12.90
1926	2,640	23,522	6,599	1,855	31,976	12.11
1927	3,163	29,153	7,373	2,377	38,903	12.30
1928	3,302	29,641	7,672	1,952	39,265	11.89
1929	3,320	31,910	7,521	1,897	41,328	12.43
1930	3,080	34,240	7,327	1,899	43,466	14.11
1931	3,138	34,220	7,630	2,859	44,709	14.60
Newark Bay Pumping Station						
1924	11,797	$41,534	$18,864	$5,734	$66,132	$5.61
1925	36,542	137,963	62,723	15,746	216,432	5.92
1926	40,114	159,989	56,821	18,561	235,371	5.87
1927	46,494	179,563	59,881	12,274	249,718	5.37
1928	53,451	174,708	57,319	11,035	243,062	4.55
1929	53,053	198,444	51,190	11,039	260,673	4.97
1930	54,763	205,620	44,292	11,260	261,179	4.76
1931	60,613	219,957	49,554	12,315	281,826	4.73
Yantacaw Pumping Station						
1924	142	$5,114	$1,001	$259	$6,373	$44.81
1925	564	20,205	3,798	699	24,702	43.74
1926	652	20,349	3,723	598	24,770	37.98
1927	874	21,602	3,863	1,479	26,954	30.84
1928	805	22,763	3,789	1,120	27,672	34.34
1929	694	24,255	3,726	1,110	29,091	41.91
1930	571	26,265	3,620	1,169	31,054	54.33
1931	639	26,637	3,677	983	31,297	50.50

Sedimentation Basins—These are designed for 1½ hours' detention for average daily flow and one hour detention for maximum hourly flow, and they receive the entire discharge from the Newark Bay pumping station. The sludge deposited in the basin hoppers is drawin off through a 20-in. sludge main and discharged into a barge at a dock at Newark Bay, from which it is towed out to sea and discharged in the ocean 8 miles beyond Scotland Light. The average moisture content of the sludge in from 90 to 91 per cent.

Maintenance of Line—The 41 miles of sewers with 163 underground structures, consisting of connection chambers containing automatically controlled regulating and tide-gate mechanism, weir chambers, venturi meter chambers, grit chambers and inlet and outlet siphon chambers, are maintained by four gangs. One has its headquarters at Paterson at the north end of the line, and the other three are quartered at Newark at the south end.

OPERATING COSTS OF SEDIMENTATION BASIN

Year	Flow, M. G.	Sludge Removed, Tons (90% Water)	Cost of Sludge Removal	Total Cost of Operating Basin	Cost Per M. G. of Sewage
1927	46,494	136,760	$45,241	$58,321	$1.25
1928	53,451	309,614	97,648	111,931	2.09
1929	53,053	421,656	116,637	132,548	2.50
1930	54,763	420,269	94,034	112,811	2.06
1931	60,613	539,942	112,253	139,789	2.34

REMOVAL OF SAND AND DEBRIS FROM 88 WEIR AND GRIT CHAMBERS AND 14 SCREEN CHAMBERS

Year	Quantity Removed, Cu. Yd.	Cost of Removal	Cost Per Cu. Yd.
1925	3,208	$7,956	$2.48
1926	3,940	11,687	2.97
1927	3,775	11,449	3.33
1928	4,801	11,740	2.62
1929	4,739	14,276	3.07
1930	5,244	12,249	2.16
1931	5,544	12,166	2.22

One gang is composed of a foreman and seven laborers, provided with a 1½-ton truck. It covers one half of the entire district each day, and its routine duties each week are divided as follows: two days raising and cleaning screens, two days cleaning weirs and 1½ days inspecting all connection chambers, greasing valves, cleaning float wells, drums and gates and miscellaneous maintenance work along the line.

Another gang covers the other half of the district and is similar to the first in make-up, equipment and duties.

A third gang consists of four men who operate two 7½-ton auto dump trucks, one of which is equipped with a crane and orange peel bucket. This gang covers the entire district and removes the sand and debris from the 88 weir and grit chambers and 14 screen chambers, hauling it to the nearest local dumps. The sewage, as it flows from one end of the system to

Fig. 3—Diagram showing the increasing quantity of sewage handled by the system, together with the total cost of operation.

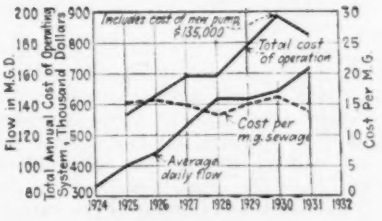
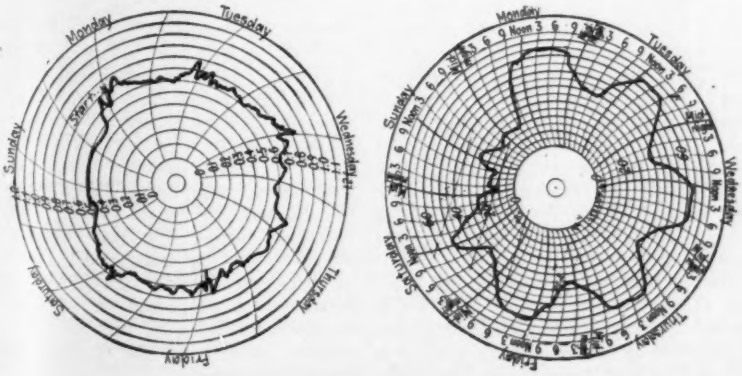

Includes cost of new pump, $135,000
Total cost of operation
Cost per m.g. sewage
Average daily flow
Flow in M.G.D.
Total Annual Cost of Operating System, Thousand Dollars
Cost Per M.G.
1924 1925 1926 1927 1928 1929 1930 1931 1932

Fig. 2—Typical flow records of the sewer system. The left chart is a record of the head on the weir, measuring the sewage contributed by East Rutherford. The right chart indicates the flow in million gallons through the venturi meter in the main sewer at Paterson.



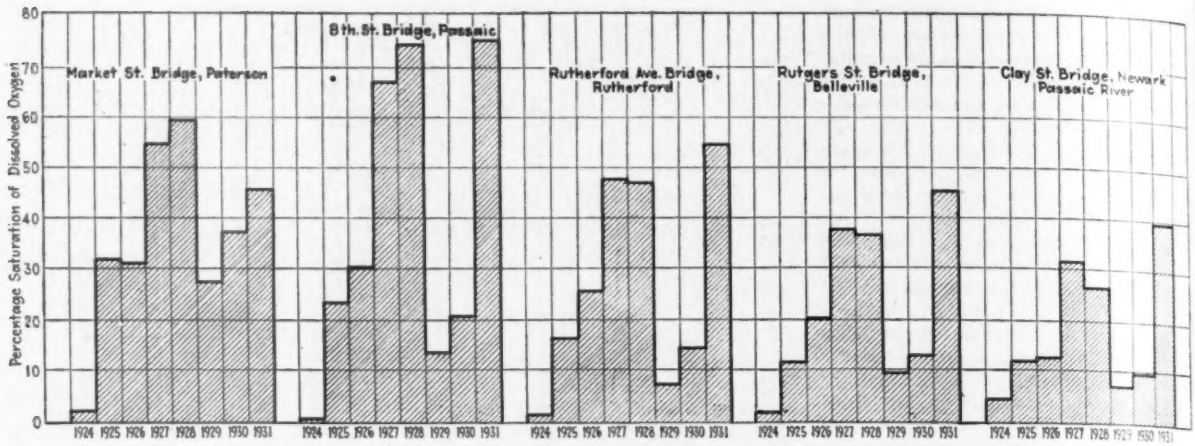

Percentage Saturation of Dissolved Oxygen
Market St. Bridge, Paterson
8th St. Bridge, Passaic
Rutherford Ave. Bridge, Rutherford
Rutgers St. Bridge, Belleville
Clay St. Bridge, Newark
Passaic River
1924 1925 1926 1927 1928 1929 1930 1931

Fig. 4—The marked improvement in the sanitary condition of the Passaic River is shown by the oxygen content of the water as measured at three different points in its course. The low figures shown for 1929 and 1930 are explained largely by the drought during those years.

the other, passes through 15 sets of screens. This repeated screening is made necessary by the many inverted siphons constructed in the line, by the many weir and venturi meter chambers and by the three pumping stations. These screens are all of the vertical-bar type with openings between bars varying from 3 in. to ½ in. They are raised and cleaned at intervals ranging from once every hour at the Newark Bay dumping station to three times a week at the smaller inlet siphon chambers.

The fourth gang consists of two men provided with a 1-ton truck equipped with an electric generator that furnishes current for a portable centrifugal pump. This gang also covers the entire district and pumps out the seepage and infiltration water that accumulates in all connection chambers and other underground structures. When not engaged in pumping operations this gang takes samples from the connection chambers for the purpose of determining acid conditions in the incoming sewage.

Meter Department—The measuring of the flow discharged into the Passaic Valley system is accomplished by the use of 26 weirs and 16 venturi meters. Weirs of V-notch, rectangular and Cippoletti forms are used for measuring flows up to 10 m.g.d., and venturi meters for the larger flows. Each weir and venturi meter is equipped with an automatic recording circular chart, which in the case of the venturi meters records million gallons directly, and in the case of the weirs records the head on the weirs. Most of the charts record a seven-day period, though the larger venturi meter records are made on a one-day chart.

These charts are removed at the exact expiration of their periods, and new charts are installed. The completed charts are promptly brought into the main office, where they are planimetered and the flow calculations are recorded.

The field force that maintains the meters is composed of a meter inspector and three assistants. This gang is equipped with a 1½-ton truck, and covers about 60 miles each day. It inspects and tests the meters, changes the charts, cleans the debris off the weirs and does practically all repair work on the 46 meters.

At the time the system was put into operation the recording boxes containing the recording mechanism and the charts were installed in the meter and weir chambers underground. It very soon, however, became apparent that due to the moisture present in the atmosphere in these underground chambers the charts could not be prevented from wrinkling; and as a wrinkled chart resulted in an unsatisfactory record, it was necessary to bring all the recording apparatus above the surface of the ground. This was accomplished by designing heavy cast-iron meter boxes, which stand about 4 ft. above ground level and rest on a substantial concrete base. They are placed a little back from the curb line and have given entire satisfaction.

Chemical and River Control—This department consists of a chemist, an assistant chemist, eight river inspectors, one clerk and an office boy. An automobile is furnished for land transportation, and there is a 40-ft. cabin motor boat for water inspections and the obtaining of water samples in the Passaic River, Newark Bay, Kill van Kull and New York Bay. A well-equipped laboratory is maintained, and during the year 1931 more than 5,000 samples of water were analyzed for dissolved oxygen content. The accompanying charts show average dissolved oxygen content in the waters of the Passaic River during the summer months, the most critical of the year, for the years 1924 to 1931 at various sampling stations from Paterson to Newark.

The marked decline in oxygen content shown on all of these charts for the summers of 1929 and 1930 is accounted for by the severe droughts that occurred during these years; it might also be noted that the summers of 1927 and 1928 were unusually wet periods. With these climatic conditions in mind and remembering that the Passaic Valley system was first put in service in August, 1924, a progressive improvement in river conditions is evident over the eight years of operation.

That this recovery has been slow is accounted for to a large extent by the fact that in the summer of 1924 there were 422 industrial concerns located on the banks of the Passaic River and its tributaries, discharging their polluting wastes into the river or its tributaries; also there were three serious sewage-pollution centers remaining, even after all the municipal sewers in the district had been connected to the intercepting sewer. In Paterson, at the upstream end of the district, many of the combined sewers were overloaded and were continually overflowing to the river. In the Borough of Lodi, located midway downstream and not at that time a party to the Passaic Valley project, the entire discharge from the borough's Imhoff tanks was led into a tributary of the Passaic River within a half mile of its confluence with the Passaic. In Newark a large brook near its northern boundary was receiving the discharge from a 30-in. combined sewer at a point near where this brook emptied into the river.

For several years the Passaic Valley Sewerage Commissioners endeavored to eliminate these remaining pollutions by persuasive methods, and in most instances the desired results were accomplished. A few very serious pollutions persisted, and it was only after resorting to legal action that the final diversion of all sewage and polluting trade wastes from the river was accomplished.

At the present time it may be stated that the entire polluting discharge from the Passaic Valley Sewerage District is either turned into the intercepting sewer or is being satisfactorily disposed of by means of modern efficient sewage-treatment plants, and a wholesome, sanitary condition of the once grossly polluted waters of the Passaic River has been restored.

Planning and Economics Dominate at Civil Engineers' Meeting

Development problems of the Philadelphia-New Jersey region and public-works finance discussed by five divisions at Atlantic City

IN FIVE divisional sessions and two general sessions the American Society of Civil Engineers in its Atlantic City meeting last week covered a wide range of subjects, including public-works economics, highway and street traffic problems, sewerage, water resources, railway terminals, city planning and regional development. The treatment of these subjects, however, centered mainly around the two themes of planning and economics. This theme first came to the front in the addresses at the society's formal dinner.

Special addresses

Opening the dinner symposium, Charles D. Marx, chairman of the Reconstruction Finance Corporation's engineering board, sketched the difficulties that beset the board and asked general sympathy and help. The board early found, on sifting the 300 or 400 projects submitted, that most of them lacked the necessary engineering information, and that many had to be thrown out as quite outside the general requirements of the law. As the board could not do the engineering work required to perfect applications and did not want to build up a large staff, it drafted a circular of instructions (circular 3) to remedy the situation. Nevertheless, applicants have been slow to supply the needed data. The board has worked day and night and is doing everything in its power to expedite results. For further aid the directors of the R.F.C. have instructed each local R.F.C. representative to add an engineer to his staff to advise applicants how to proceed.

Willard T. Chevalier, speaking on teachings of the depression, gave first place to the fact that much accepted knowledge has been proved wrong, and that many principles thought to be fundamental are now seen to be mere expediency embalmed in tradtion. A plastic mind, he said, is vital to an understanding of the day's great changes.

Turning then to construction, or the increase of fixed capital investment, as the best guarantee of the prosperity of business, he pointed out that the usefulness of the construction dollar in creating purchasing power is not, as in the case of the production dollar, neutralized by dependence on further increase in consumption.

Challenging the indiscriminate tax-reduction demands that are current, Colonel Chevalier made spirited defense of the public servant and praised his efficiency, devotion and economy over those of private business. Public service, animated not by desire for profit as is private business, but by devotion to the service ideal, is represented in highest form by engineers like Holland and Slattery, who sacrified health and life to this ideal.

Elisha Lee, vice president of the Pennsylvania Railroad, opened his address by challenging the belief that the railroad may soon go the way of the stagecoach and the Conestoga wagon there is no present prospect that the railroad will lose its place as our main instrument of transportation, he said. But the rapid growth of highway and waterway competition is cause for concern. The problem should be appraised dispassionately and thoroughly. Highway competition is a world-wide phenomenon; some other countries are ahead of us in dealing with it, however. The recent report of the Salter commission in England is a significant pointer. In this country the Association of Railway Executives has appointed a committee of four railroad presidents to confer with automotive interests and road users in working out a solution.

Railroads, far from being hostile to highway transportation, ask only equal terms, Mr. Lee declared.

C. N. Lauer, president of the American Society of Mechanical Engineers, made an earnest plea for a united engineering profession and for more careful selection of its personnel. The Engineering Council for Professional Development is a new agency for the latter purpose, having the function of studying the factors that should govern admission to the profession.

Progress in planning

An exposition of the work of the Philadelphia Tri-State District in developing a regional plan, which occupied an entire session, gave a keynote of planning to the meeting. This exposition was supplemented by a review of the large-scale planning involved in railroad terminal modernization in Philadelphia, by Robert Farnham, chief engineer of Philadelphia Improvements, Pennsylvania Railroad.

The Tri-State District, or Philadelphia region, comprises eleven counties in Delaware, Pennsylvania and New Jersey, containing 4,500 square miles. Private interests associated themselves in 1926 for a study of the region and development of a master plan, which plan was completed and made public last March. Wm. H. Connell, executive director of the Regional Planning Federation, Philadelphia, described the work as comprising a study of population growth, layout of a system of major thoroughfares, parkways and bridges, planning of main railroad facilities, waterways, ports and air landing fields, and study of the requirements of water supply and drainage.

Samuel P. Wetherill, Jr., former president of the federation, outlined the origin of the movement and the major steps in obtaining cooperation of all interested parties and in gaining popular support for the movement. The necessity for planned priorities for public improvements was recognized by Samuel Rea and other public-spirited citizens of Philadelphia, whose support enabled the federation to be organized.

New Jersey's share in the evolution of the plan was indicated by Henry J. Sherman, of the New Jersey board of commerce and navigation, who said that with 2,000 square miles and 640,000 people in this part of the region, New Jersey had in the main a conservation problem. Allan P. Shaw, county engineer of New Castle County, Wilmington, Del., described the establishment of a county planning body there and its present work in devising a county plan coordinated under the Tri-State plan. Rediscovery of the Maryland-Delaware boundary was a feature of the surveys, and with it some roads were discovered to be in Delaware that had been believed to be in Maryland.

H. M. Lewis, of the Regional Plan Association, New York, pointed out the value of broad financial support in furthering cooperation for execution of the plan.

Surveys for planning

R. V. Black, of New Hope, Pa., at a joint meeting of the city planning division with the surveying and mapping division, detailed the basic surveys and data required in city planning. Only a preliminary plan can be made from the maps normally available, he said; the final or master plan requires a full survey, producing a line map of 200-to-800-ft. scale, an air map to the same scale, fair topographic data (preferably a precise topographic map of 200-to-400-ft. scale), and special maps such as use maps. The area of influence at the perimeter should be included.

E. P. Arneson, of San Antonio, Tex., listed the required data for the development of a city plan thus: a photographic air map of 600-ft. scale, an accurate topographic map, special maps, rainfall, wind and flood records, population and traffic counts and an industrial survey. Discussing some of the desirable features of planning, he advocated provision for exclusive motor-truck thoroughfares.

R. N. Clark, city engineer of Hartford, Conn., in discussion drew attention to the municipal engineer's difficulty in getting funds to make the basic surveys for planning unless he can show that the work will bring a cash return.

Engineering and the depression

Special interest centered in the meeting of the engineering economic division because the subjects under discussion were closely related to the welfare of practically all the profession.

Reasons for the collapse of public-works construction in the years 1929-31 and the effect of collapse on general business conditions were clearly outlined by Malcolm Pirnie in a paper on public-works financing. Almost complete cessation of private construction was somewhat offset in 1930 by the administration's efforts to maintain public construction as a means of relieving unemployment, but this effort failed when the drive against all public construction was begun by real-estate interests in 1931. The latter culminated in the now-famous resolution of the Investment Bankers Association opposing all public construction and effectively closing the door to financing any public work by municipal bond issues. "So thoroughly had business men become convinced that public expenditures must cease in order to reduce taxes that it was futile to argue economic principles with them," said Mr. Pirnie. "The laborer digging a sewer trench was to them a symbol of increased taxes instead of a purchaser of commodities they needed to sell in order to pay taxes."

Efforts to revive construction

Efforts of the American Water Works Association, the American Society of Civil Engineers, the Construction League and the Committee for Trade Recovery were described briefly by Mr. Pirnie. Passage of the Emergency Relief and Construction Act of 1932, providing for the construction of needed federal public work and the financing of self-liquidating projects, was the result of these activities, but, in Mr. Pirnie's opinion, the tax limitations of that act must be amended before it can be made fully effective.

"In the future," said Mr. Pirnie, "surplus accretions should be heavily taxed by state and federal governments, except in cases where it can be demonstrated that normal demand exists for extension of productive facilities. The money collected by states from this source should be apportioned annually through a state planning board to the various political subdivisions, to be invested in public works complying with approved long-time plans of municipal, county and regional planning boards coordinated with state and federal plans. The work done in any year should be limited to the money available, thus abolishing double payment through interest and amortization of bonds. Self-liquidating public works would not be included.

"Money derived by the federal government could be applied to effect the needed construction of public works in those states whose revenues fall below the general requirements of the nation as a whole, and a definite proportion of it can be applied to the purchase of newly mined gold for a stabilization account in the Treasury."

Investment in public works

Carrying charges on the country's investment in public works amount to only about one billion dollars, said John P. Hogan in a paper on the relation of investment in capital facilities and construction to the economic scheme, while the annual expenditure for government, including federal, state, county and municipal disbursements, is in the neighborhood of thirteen billion dollars. It would appear, therefore, he said, that taxpayers' associations in opposing public construction have been hacking at the small limb of the tree rather than at the main trunk, the operating expense of government.

"The country," Colonel Hogan said, "is still in the development stage, and construction work constitutes about 20 per cent of our normal prosperity. We cannot, therefore, have what we consider normal prosperity without construction activity. Our normal annual building program is about nine billion dollars, or about one-tenth of our normal annual income, and the business created is many times the nine billions. During 1932 the indications are that we will spend less than three billions in construction work."

After reviewing the deflationary period in its special relation to public works, Colonel Hogan said: "We will gradually arrive at a consciousness that public works, and certain public utilities, represent in general the only permanent increase in national wealth. Additions to productive facilities, on the other hand, remain wealth only so long as customers can be secured for the output.

"All these things will be appreciated in their proper light when we come to the realization that, after all, the only permanent benefit that can accrue to us as a nation is not in the building up of large fortunes but in improving the average well-being of our people."

Compulsory reserve funds

The third paper before the engineering economics division was one by Frederick H. McDonald, Atlanta. In his absence it was read by the chairman, Willard T. Chevalier. Mr. McDonald took as his subject combining compulsory corporate reserves with public-works construction as a means of obtaining economic stability. "We are in a position," he said, "where private enterprise has an expanded capacity which almost overnight could produce unconsumable quantities of our present-cost goods, even on a highly inflated basis of consumption. The only source of available construction not on a consumer basis is providing new public-works facilities. Since the World War, industrial and commercial facilities have advanced to a point momentarily far in excess of current needs, but only in a few instances have community facilities been advanced to the point of meeting normally accepted minimum standards. This means that in times of general business depression a great volume of business creating new construction could be released if communities of the country were financially in shape to obtain the money.

"This brings us to the inescapable conclusion that if in time of economic depression the normal market could be maintained for reasonably good state, county and municipal securities large volumes of construction work could be released."

Bond trust proposed

To meet this situation, Mr. McDonald proposes a municipal-bond investment trust in which local government securities would be pooled against the certificates of the trust. These certificates, he believes, would find wide acceptance for investment of funds demanding high security at low return. Further he proposes to make them acceptable as collateral for the issuance of currency by national banks.

Another large source of funds for investment in these trust certificates is the reserve funds built up by corporations for the stabilization of business operations. Mr. McDonald is the author if a plan for business stabilization which proposes the setting up of compulsory reserves during periods of prosperity by withholding from distribution all earnings in excess of the state legal rate of interest on invested capital or appraised value of assets until the reserve has reached an amount equal to a minimum of one year's salaries, wages and primary dividends. This reserve he proposes to distribute in times of depression at one-half the normal rate, thus providing half-pay on both capital and labor over a two-year period.

Discussion centered chiefly on the problems involved in setting up reserves such as were proposed by Mr. McDonald and arpund improvement of present methods of financing public works. J. N. Chester, Pittsburgh, expressed the view that compulsory impounding of part of the wage-earners' income, as proposed in the Swope plan, is essential to stability.

In summing up the three papers and the discussion, the chairman, W. T. Chevalier, said: "A choice between three methods of using our surplus confronts us. First, there is that of the *laissez-faire* group who would not interfere with natural processes but would let periods of depression develop to consume

the surplus. Second, there are the moderates who would store up our surplus and sterilize it in some way, holding it to use to level off the valley of depression. Third, there is the radical group, those who would find a way to curb the building up of surpluses through converting the new wealth we are creating into consuming power."

Traffic control

A modern view of highway and city street-traffic control was given in two papers by J. L. Bauer, state highway engineer of New Jersey, and Burton W. Marsh, traffic engineer of the Philadelphia safety department. Advanced practice was reflected in both papers, as New Jersey is prominent in the development of through-traffic routes, special intersections and bypasses, while Philadelphia is engaged in an aggressive attack on its traffic problems, with thorough use of engineering methods.

Mr. Bauer, after speaking of the undesirability of carrying main roads through cities and villages, showed by examples how the layout of bypasses is governed by local topography and other conditions. New Jersey main roads are now preferably laid out for 80-ft. width, with two 28 ft. three-lane traffic strips separated by a 25-ft. central space. This layout has in many respects proved very successful in operation.

Mr. Marsh outlined by pictures and statement the wide range of engineering analysis necessary for proper handling of city traffic control for safety and traffic efficiency. The situation is rendered more difficult by lack or inadequacy of drivers' license examinations, by non-uniformity of signs and markings, by absence of truck and bus regulation as to speeds, working hours, size and weigh of loads, and by the inadequacy of municipal traffic regulations coupled with the tendency to promulgate detail rules by ordinance instead of by administrative regulation. He emphasized that engineering methods should be the principal basis for regulation.

Does highway improvement pay?

Methods and data for the economic study of highway improvements were outlined by Dean Thomas R. Agg, of Iowa State College, in a paper on estimating the economic value of proposed highway expenditures. He dealt with improvement of surface, relocation to reduce distance, and reduction of gradient. The methods outlined apply to specific improvements. Attempts to estimate the total cost and productivity of the entire highway network are now being made by a number of Western states, but generally the facts must be worked out for individual roads.

The value in saving of distance is estimated at 2½c. per vehicle-mile for high-type and 3c. for intermediate-type surfaces (for trucks 8c. and 13c.).

Cost of delays led to some discussion, but Dean Agg reported that there is still wide disagreement on the subject. As Arthur Richards, of Trenton, pointed out, a large item of transportation cost is added by delay at traffic lights. In specific instances, which he cited from Mercer County, N. J., lights reduced the traffic capacity at an intersection from 1,800 to about 1,600 vehicles per hour.

Road-cost calculations by the methods of the paper, Dean Agg concluded, can be used as a basis for fixing the proper contribution to road costs of the several classes of traffic. His calculations included no factor for difference in injury to the road by light and heavy vehicles.

Regional sewerage

Increasingly serious pollution of the Hackensack River and its tributaries and resulting demands by New Jersey state health authorities for abatement of pollution has led to study of sewage disposal for the entire region. As outlined in a paper by George W. Fuller, of New York, the solution was found in separate trunk sewers for the upper and lower halves of the stream basin (because of the necessity of flat slopes in the low ground), with two treatment plants. The latter may be of the activated-sludge type, but chemical precipitation is also being considered for the lower plant, which will discharge into tidewater. It is proposed that the counties build the works and charge the municipalities served on a volume basis.

T. Chalkley Hatton, of Milwaukee, suggested that charges on a flow basis do not allow for the influence of undeveloped property; Milwaukee is planning to obtain legislation to permit charging on a more adequate basis. He urged also that the commission in charge of the project should have final power to determine its budget, this to be mandatory on the county supervisors. Milwaukee would not have had a dollar in the last two years if the county authorities were in control of the budget. Charges in Maryland, E. B. Whitman stated, are composed of a general-benefit charge, a graduated frontage charge and a connection charge; there are three joint sewerage districts. H. P. Eddy, of Boston, commenting on population estimates, said that despite predictions of decreased rate of growth he is sufficiently optimistic to use figures and curves not much out of line with those used in the past; the pessimism of the present moment should be disregarded.

On possibilities of R.F.C. financing of sewage disposal projects, H. R. Buck, of Hartford, said that a recent decision of the corporation's legal department classes sewers (but not roads) assessed on a frontage basis as self-liquidating.

Sewage disposal along the beaches of New Jersey, as outlined by Chester G. Wigley, of Atlantic City, former chief engineer of the state board of health, has to deal with 170,000 resident and 600,000 summer population.

Treatment is by sedimentation or screening followed by disinfection; only one plant has further treatment, by sprinkling filters.

Water problems below Philadelphia

Problems of water supply and sewage disposal in Delaware County, Pa., were presented to the second session of the sanitary division by Harry M. Freeburn, district engineer, Pennsylvania department of health. Delaware County adjoins Philadelphia to the south. Its sanitary problems are chiefly those of a growing suburban residential and commercial district. Sewage disposal still is largely by dilution in the many small streams flowing into the Delaware. Part of the area gets its water from the Philadelphia Suburban Water Co., but Chester, the most important city of the county, takes its water supply from the Delaware. Despite increasing pollution, it has been successful in delivering a satisfactory water biologically to its citizens and is now making heroic efforts to free the water from the unpleasant taste and odors that have come with the greater industrial pollution of recent years.

George D. Norcom, engineer, Federal Water Service Corp., owner of the Chester Water Service Co., outlined the fight the company has made to improve its product. In recent months attention has been devoted to taste and odor elimination. Use of ammonia has produced definite benefits, but it is not effective in cold months. Experiments with activated carbon have not been particularly successful. The use of bleaching clay was commenced in December, 1931, and results obtained to date have been remarkably effective, Mr. Norcom stated.

Alexander Potter, New York, stressed the significance of what the Chester Water Co. is doing in development of the sewage-water cycle. Under conditions such as are found along the lower Delaware he believes that sewage treatment must be more complete in order to take part of the load and expense off the water plants.

Coastal plain groundwaters

New Jersey having few streams in its southerly part, water supplies from groundwater increased from 10 per cent of the state's total in 1894 to 30 per cent in 1931, as reported by H. T. Critchlow, of the state water policy commission, in a paper on groundwater resources of New Jersey. Wells in the coastal plain draw from the 100- to 200-ft. level and from the 700- to 850-ft. level.

In discussion, J. N. Brooks, Trenton, gave the specific well capacities realized in southern New Jersey as 25 to 60 gal. per minute per foot of drawdown, while wells in rock at Garfield show only 2 to 7.

D. G. Thompson, of the U. S. Geological Survey, stated that no extensive

quantitative studies of groundwater resources were made in the East after the Freeman-Spear-Veatch studies of 1900-1912, until work was begun by New Jersey in cooperation with the federal government in 1923.

John C. Hoyt, of the U. S. Geological Survey, expressed a warning on drought possibilities. Study of hydrologic records indicates that any section of the country may experience droughts like those of 1910 and 1930-31 in such close succession as to require supplies to be planned for drought conditions.

Washington incinerators

Harrison P. Eddy, Jr., of Boston, described the new Washington refuse incinerators, which were built on engineer's design after the Comptroller-General had ruled out bids on bidders' designs as illegal because they left determination of compliance with specifications to the discretion of the awarding officer after opening of bids. The second bidding showed a large reduction of price over the first bidding. The two incinerators are now completed, and that at Georgetown is in operation.

On the matter of engineer's against bidders' design, George W. Fuller, of New York, recalled the early condition of water filtration. At first, bidders' designs were used under guarantee, a matter that proved capricious to handle. Later he designed the Hackensack filters without bidders' designs. Later a combined practice was followed, the engineer's design being so worked out that the bidder was free to provide his own mechanical equipment. This worked well and gave opportunity for cooperation of the equipment manufacturer with the engineer.

The convention closed with a well-attended student chapter conference. Saturday was given over to visiting points of interest in Philadelphia.

Metal Structure and Stress in Welded Joints

Fall meeting of American Welding Society in Buffalo notable for papers of scientific character—F. P. McKibben presented medal for achievements

WHILE the program of the annual fall meeting of the American Welding Society, held in Buffalo, N. Y., Oct. 3-7, did not involve as many structural welding papers as formerly, it contributed important knowledge concerning some of the fundamental welding research that is being carried out in the various university laboratories. Also F. P. McKibben, the present president of the society, whose activities have been almost entirely in the structural welding field, was awarded the Samuel Wylie Miller medal for meritorius achievement which "has contributed conspicuously to the advancement of the art." For 32 years in the profession of teaching (thirteen years at Massachusetts Institute of Technology, twelve years at Lehigh University and seven years at Union College) Professor McKibben has also been occupied with consulting work and in recent years has taken an active part in the development of structural welding in his capacity as consulting engineer for the General Electric Co.

The attendance was smaller than in other years, but exhibitors at the allied Metals and Welding Exposition reported a satisfactory number of inquiries and the average amount of new business.

In the part of the program devoted to fundamentals of welding research all of the papers contained new information that should be on record. These papers are abstracted below.

X-ray examinations

A paper on the X-ray determination of stresses in welds, by John T. Norton, associate professor, department of metallurgy, Massachusetts Institute of Technology, considered the specific question of utilizing "pinhole" photograms obtained with narrow beams of X-rays. Properly interpreted, these exposed films give information concerning grain size and grain orientation. Knowledge of local deformations of the grains is important in welding when questions of impact resistance and fatigue resistance are being considered. On film, exposed through weld metal which has been deformed, elongated spots appear, arranged in a general radial direction. This phenomenon has been called asterism, and it indicates that the planes of atoms in the crystal grains have been deformed. Professor Norton explained that elastic deformations in a metal cannot show as asterism but that plastic deformation is thus revealed. The method therefore is not of much value to show elastic locked-up stresses, which are of vital concern to the designer. However, it does indicate the degree of perfection of the grain, which is an important factor when weld ductility is being considered. Professor Norton pointed out that in this particular X-ray method there is available a means of isolating and studying one particular property of the metal sample (grain deformation) independently of all others.

Metal deposition in arc welding

The question as to whether the deposited weld metal passes through the arc as vapor, as a mist or as globules larger than mist, and the existing uncertainty as to the nature of the driving force of the transfer, particularly in overhead welding, were considered in a paper by Prof. Gilbert E. Doan, of Lehigh University, and J. Murray Weed, of the General Electric Co. The paper described a method of investigation which is believed to disclose all of the possible forms in which metal is transferred through the arc. A polished metal strip or metallic mirror was moved under the welding arc so rapidly that all of the forms of metal deposition were distinctly separated from one another on the surface of the strip. Each form retained its identity and was easily recognized, the mirror thus giving a continuous and chronological record of the character of the deposit. The studies indicated that liquid globules are the chief form of metal transfer, although there is some metal transfer (perhaps 10 per cent) in vapor and mist. A bare, or very lightly coated electrode was used. It is the authors' belief that globules are also the chief form of transfer when coated electrodes and the necessarily longer arcs are used.

Oscillographic records of the instantaneous values of the current and voltage of the arc accompanying each series of depositions were taken. These revealed several things, among them that the size of the current disturbance on the film corresponds quite well with the size of the globule deposited on the strip. Current peaks are of course accompanied by voltage valleys and vice versa. The largest current peak is usually the first one, possibly indicating the transfer of accumulated liquid at the tip of the electrode, according to the authors.

Corrosion fatigue

In investigating welds the usual mechanical testing methods have been supplemented by such non-destructive testing methods as the stethoscope, the X-ray and the gamma ray, and in one or two instances in studying dynamic loads upon a welded structure, fatigue investigations have been made. A paper by Wilber E. Harvey and F. Jerome Whitney, Jr., Lehigh University, added some entirely new information on corrosion fatigue of welds. Corrosion fatigue is defined as the highest stress that a metal will endure indefinitely (say, for 10,000,000 cycles of stress) when sub-

jected to repeated stresses and exposed simultaneously to the corrosive influence of a stream of water.

Fire-box quality steel was chosen as the stock metal in the investigation, and five types of welding were tested: (1) covered-wire arc, (2) bare-wire arc, (3) atomic hydrogen, (4) gas, (5) electric resistance. The R. R. Moore rotating-beam-type fatigue machine was used in all the tests. The steel contained about 0.2 per cent carbon. The water used as a corroding medium was Bethlehem city water, which is substantially a carbonate water. The water was applied directly upon the plane of maximum stress, which was in every case the location of the weld.

Corrosion-fatigue limits were as follows: covered-wire arc weld, 14,000 lb. per sq.in.; bare-wire arc weld, 9,000 lb. per sq.in. (these welds were found to lack a good cross-section, which may account for the low value); atomic hydrogen welds, 17,000 to 18,000 lb. per sq.in.; gas welds, 19,000 lb. per sq.in.; electric resistance welds, 24,000 lb. per sq.in.

From these results it was concluded that the effect of welding upon the corrosion-fatigue limit of the low-carbon steel is not deleterious except in the case of the bare-wire specimen. Fatigue-in-air studies, on the other hand, of similar welded material have shown that in all cases the fatigue limit of the unwelded material was very considerably lowered with the presence of a weld.

In every type of weld, with the exception of electric resistance welds, the corrosion-fatigue limit of the respective types of welds was higher than the fatigue limit in air. In the electric resistance welded specimen the fatigue limit in air was very slightly higher than the corrosion-fatigue limit.

Grain size did not seem to have any effect upon the corrosion-fatigue limit of the welded materials.

Impurities such as slag particles lower the resistance of the welded material to the combined action of corrosion and fatigue stresses.

Stress distribution in butt straps

A study undertaken to determine the elastic distribution of stresses in various types of butt-strap joints was reported by S. C. Hollister and A. S. Gelman, of Purdue University. From the standpoint of the structural engineer this paper was the outstanding one of the meeting. The tests were laid out to compare other forms of splice plates (diamond-shaped and rectangular straps welded four sides) with the widely used side-welded splice plate that has been shown to give very irregular stress distribution. The relatively high stresses near the ends of side welds, found in earlier investigations, were confirmed in the Purdue studies.

Preliminary and supplementary to the full-sized steel specimen tests, celluloid models of the joints were prepared and studied in polarized light. These studies gave a good picture of the stress-flow lines for the main plates and influenced to some extent the design of the full-sized steel-joint specimens. Deformations in the latter were measured by means of Huggenberger extensometers on ½-in. gage lengths.

Some of the conclusions were as follows:

In certain types of joints tested a variation of stress distribution was found in main plates, spliced plates and welds, to such a degree as to make desirable a consideration of stress concentrations in designing welded joints.

In splices with side fillets only the variation of stress was of such magnitude as to justify, in the case of a structure subjected to repeated loads, a larger quantity of welding than that required by customary design. This additional welding should take the form of increased fillet length.

In side-welded rectangular splicing, with a total length of splice plates less than twice the width of the specimen, butt straps should be at least as thick as the main plate, the latter being designed for reduced unit stresses.

Splices with closed-contour welds show better distribution of stress throughout the entire splice.

Transverse and side welds when used in the same joint participate to about the same extent in transferring the load.

The preference for side welds does not seem to be justified, as the stresses carried by a side weld are complex and of high magnitude, and even the ultimate strength of the side welds when tested alone is lower than that of transverse welds tested alone. A combination of the side and transverse welds is more desirable than side welds alone.

Diamond-shaped splices show the best distribution of stresses in all elements of the connection with no concentration of stresses on free edges, and it may be considered the most suitable type of connection for structures where rigidity of a joint and capacity to withstand repeated loads are of major importance.

General papers

In a paper on the chemistry of low-carbon arc-weld metals, J. C. Hodge, Babcock & Wilcox Co., emphasized the widely varying chemical compositions available and the necessity for describing the weld metal by the degree of protection from contamination by atmospheric gases. By varying the efficiency of the protection, either by varying the nature and thickness of surface coatings and coverings or by changing the length of the arc, the composition of the deposited weld metal may be changed at will. Thus the nitrogen content may vary from 0.015 to 0.15, depending upon the degree of protection. Other changes in chemical composition occur during weld deposition—for example, the carbon and manganese are considerably lowered, indicating the extreme oxidizing conditions within the arc. Variations in chemical composition affect the elastic properties and the behavior under plastic deformation of the various weld metals.

Automatic welding with heavily coated electrodes was described by Laurence R. Leveen, of the General Electric Co. Until recently no automatic head for welding with heavily coated wire has been available for production purposes. One has now been developed, permitting the use of standard coils of wires in which threads are interwoven in the coating to eliminate the danger of cracking or flaking of the coating. The head is of the magnetic-clutch type, enlarged and strengthened for the heavier duty required. Multiple-drive rolls, together with a current-conducting unit, are all combined into one piece of equipment. Typical operations are said to show higher speeds than with bare-wire welding and at the same time to give all the desirable characteristics of heavily coated electrode welds such as increased tensile strength, greater ductility, denser metal, and more resistance to shock load.

A load test on the novel truss developed for a new building at the Derry, Pa., works of the Westinghouse Electric & Manufacturing Co. was described by Charles H. Jennings, of the Westinghouse laboratories. A brief account of this work was given in *ENR*, Aug. 4, 1932, p. 136. The novel feature of the truss is the use of tension members constructed from several continuous straps disposed throughout the truss so as automatically to increase the cross-sectional area of the various members in proportion to the load that they carry. The trusses tested are of the Warren type, but it is said that the same construction can be used effectively on other type trusses, such as the Pratt, Fink and Fan. Mr. Jennings' report of the tests indicated that the actual stresses in the members of such a truss agree very well with the theoretical stresses computed by means of standard methods, and that the secondary bending stresses in the members are relatively low because of the flexibility of the tension members and the joints. He pointed out that careful fabrication specifications are required to insure that all tension straps be kept straight, to the end that undesirable redistribution of stress may not occur in some of the composite members.

A paper on "Welded Roll-Steel Design for the Iron and Steel Industry," by Christian A. Wills, The William B. Pollock Co., revealed how welded construction is being used on open-hearth ladles and the supporting cars, the striking fact being the assured confidence with which welding is applied in a field where a failure would be so disastrous to life and property.

Engineering News-Record

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An Engineer's Contributions

TWO notable achievements stand as a fitting climax to John R. Freeman's rich and many-sided career—bringing about the construction of the hydraulic laboratories at Vicksburg and Washington, and rousing the seismological world to a determined attack on the menace of destructive earthquake forces. The keen mind, indefatigable activity and forcefulness that accomplished these results were characteristic of all he did, whether at Panama or along the Mississippi, in Boston and New York water areas or at Hetch Hetchy. Though his two last contributions form only a small part of his service and legacy to the world, it may be that the future will show them to be of greatest utility, for they promise to solve many of our large problems of hydraulic engineering and to make possible the first major step toward protecting mankind against earthquake ruin.

Three Months' Work

WITH grant of a loan to the San Francisco Bay bridge, the R.F.C. now has approved seven self-liquidating projects, of total ultimate cost approaching 130 million dollars. The latest loan is subject to the peculiar condition that the state provide the remainder of the construction money and that all bridge income be pledged against the R.F.C. loan, which means that the project is to rest partly on tax moneys—notwithstanding the clear prohibition of the self-liquidating clause of the act—and may require state legislation. Similarly the two other major projects, the Los Angeles aqueduct and the New Orleans bridge, have legal hurdles still to surmount. Looking thus at the result of three months of the R.F.C.'s trusteeship of one and a half billion dollars, one is left with little hope that it will in any measure relieve the winter's unemployment problem. The help and sympathy that the chairman of the engineering board asked of his professional brethren at Atlantic City last week are unquestionably due, and as surely will be given; but it is clear that at best this help will apply to next year's problems and cannot be useful in relieving the country's present emergency.

The Spirit of Circular 3

INASMUCH as high government authority some time ago declared the construction section of the Relief Act, Title II, to be unworkable, the scarcity of loans to date merely confirms what some people appear to have expected. Whether the act is slow to operate mainly because of its terms or mainly because of its application is less important than the net effect—namely, that the act has proved an utter failure as a means of emergency relief. It was known two months ago that the requirement of self-liquidation without dependence on taxes would impose very great difficulties; but as the Administration rigidly insisted upon it, the requirement was hopefully accepted. It is now known that procrastination and meticulousness in applying the act have made the difficulties almost insurmountable, and the conclusion cannot be escaped that if the act is to be of service it must be amended. No legislative provision, of course, can keep lawyers and administrators from deferring urgent decisions for many weeks, or engineers from quarreling over pipe sizes. But the law can remove the occasion for such pettifoggery by workable liberalization of conditions and by such definition of the place of assessments, gas taxes, municipal service charges and the multitude of other practical questions that the spirit of Circular 3 can be laid to rest.

Considering Regional Engineering

AN IMPRESSIVE display of the place that regional study and regional engineering has come to occupy in today's public concerns was afforded by the American Society of Civil Engineers' meeting last week. The New Jersey-Philadelphia region gave favorable opportunity for this display, and the program made the opportunity real, to good effect. Nearly all of the program—in a large sense even the engineering-economics discussions—centered about problems far beyond the individual project. In view of the steadily growing importance of plans and developments that involve a whole countryside, this fact is gratifying. Apart from such broad movements as the Tri-State plan, many matters are coordinated regionally by state control, as the Delaware County and Atlantic Coast sewerage systems. Even much that is essentially local in character is affected by regional conditions. Study of regional problems and development of sound principles and methods of regional engineering thus are progressively assuming a major position.

Knowledge Is Lacking

A WARNING of serious import was contained in the discussion of groundwater resources at Atlantic City. With increasing dependence of many regions on subsurface waters, we face the fact that little knowledge is available as to the factors that influence their usefulness. Essential facts about groundwaters are too little known for adequate dependence on these waters. Some evidence has accumulated in the last two years to indicate that drought may have far-reaching effect on the underground supplies, and that without much more extensive observation and study we may run the risk of grave water shortages. As the systematic study of groundwaters is of very recent date, and must be continued a long time without interruption to yield the needed results, it is to be hoped that this important field of governmental investigation may not suffer interruption or curtailment for lack of active citizen support.

Faith in the Future

A STRONG forward-looking spirit which found expression at two points of the Civil Engineers' meeting gave a bright color to its proceedings. The speakers foretold the certainty of undiminished progress

in the coming years, a prediction that is in shining contrast to the doubts and pessimistic forebodings heard only too often. When the gloomy prophet gets specific he cites census records and predicts that city and national growth will slow up to permanently reduced pace. "We must expect less building in future," he says. H. P. Eddy dissented from this view in practical terms; he declared that in forecasting rates of growth he uses figures and curves little different from those of the past. Growth will continue as in earlier years, he believes. The same spirit was expressed in other terms by Willard Chevalier, who affirmed his unshaken faith in the country's expansion. Such statements are encouraging signs of a new attitude and a new day. The hesitancy that is retarding the country's revival is the outgrowth of loss of faith in the future and will disappear when men are once more imbued with that faith.

Public and Business Finance

THE ECONOMIC discussion that occupied one of the strongest sessions of the Atlantic City meeting gave convincing proof, if more conviction were needed, that private business has as much need for investigation and reform of its finance and economic guidance as public business—and perhaps more. Events have shown on a country-wide scale that public administration and construction is powerfully affected by what goes on in private business; that if the latter is mismanaged by overexpansion, public business also suffers and thousands of engineers, planners and builders are made to feel the effects. When private business unwisely makes production its fetish, public construction becomes involved in the sequel. The two forms of business are so intimately related, in short, that whoever is concerned in the sound conduct of one must concern himself also with the other. Since all engineers who have anything to do with construction now recognize their vital interest in public-works and public-service economics, it appears that they have an interest also in the policies of private industry and business. And present experiences suggest that these are in need of some revision before they can claim to be sound.

Careless Bidding

THERE is a growing tendency in the award of construction contracts to give consideration to more than a mere bid figure. Qualifications, character and experience of the contractor are appraised as well as his unit prices. In this light, contractors can at least make a favorable first impression by submitting bids correctly tabulated and complying with the bidding rules set forth in the specifications. Among 32 bids received recently for a sewer project in New York state, 14 were seriously in error in extension of unit prices, mistakes as high as $100,000 occurring on a $300,000 bid. Analysis of many bids received for federal work shows an astounding number of cases where simple bidding rules had not been followed. Well-known firms of size and repute as well as obscure smaller contractors are at fault in this respect. First impressions count in contracting as well as in any other business. Obviously an engineer's or public official's first impression of a contractor, as gained through an analysis of his bid, cannot be high if the proposal is full of errors in extension or if required signatures are missing. Reliable contractors should be able to turn in a correct bid.

National Registration

NATIONAL registration of engineers was advanced measurably last week when the National Council of State Boards of Engineering Examiners at its meeting in New York approved application forms and methods of procedure that have been in tentative use since April. The National Bureau of Engineering Registration is now in shape to function on a permanent basis. How successful it is going to be depends upon how the practical problems affecting its establishment are handled. This is especially true because of the bureau's unofficial standing. Its certificates have no legal standing and cannot be substituted for state certificates.

The fundamental purpose of national registration of engineers is to facilitate the work of engineers outside their own states by providing them with a certified verification of their professional record for use in obtaining a license to practice in other states. At present most states have a reciprocal clause in their license or registration laws which permits their license boards to give due recognition to a license issued by a state having like or superior requirements for a license. Elimination of these clauses, apparently as a means of stimulating general acceptance of registration by the national bureau, was recommended to the annual meeting of the council by its committee on the national bureau of engineering registration and received qualified approval. This is a questionable procedure. Fortunately it was not accepted wholeheartedly by the council. The fact that hasty action might result in having national registration classed as a "racket" for the collection of another fee was recognized by some of those who took part in the discussion.

When an engineer seeks registration in several states, possession of a national bureau certificate may save him time and possibly some expense; but when he seeks registration only in one other state, as is frequently the case, the present reciprocal arrangement is simpler and less expensive. Further, it affords a distinct advantage that will be lost if it is abandoned in favor of national bureau certificates. The reciprocal clause in most state laws authorizes the issuance of a license to a licensee from a state having equal or higher license requirements. State requirements range from very high, as those of New York, to much less severe, as those of some agricultural states. The present arrangement permits an engineer in one of the states having low standards to be licensed in an adjoining state of similar standards, but the national bureau must set and has set its requirements high—so high that many engineers now licensed in states where most of the engineering work is relatively simple could not qualify for registration with the bureau. To eliminate the reciprocal arrangement, therefore, would only add to the difficulties of men in states having low standards who sought registration in other low-standard states. It would give the engineer from the high-standard state an undue advantage in obtaining registration in other states.

There appears to be a distinct advantage for a small number of engineers in national registration in some form, even though unofficial. Further, it will help in a measure to unify registration requirements. These advantages, however, do not yet warrant sacrifice of any of the advantages of the present system. Attempts to force the bureau's growth now may result only in its untimely death. It must develop to fill a definite need, not to create a need.

NEWS OF THE WEEK

Bridge Over Bay at San Francisco Gets Finance Loan

FOUR important loans for self-liquidating projects were authorized by the Directors of the Reconstruction Finance Corporation during the week ending October 8. Two were of major importance: one of $62,000,000 to the California Toll Bridge Authority, a public body, for a bridge across San Francisco Bay to Oakland via Goat Island, and the other a loan of $5,784,000 to the Middle Rio Grande Flood Control District for flood control and irrigation work. The other two loans authorized were $645,620 to Ogden, Utah, for improvements and additions to its water supply system, and $50,000 to Prescott, Arizona, for like purposes.

Bridge over seven miles long

The San Francisco-Oakland Bridge is planned to span the 5-mile water barrier between San Francisco and the municipalities on the east side of the bay. It will have a total length of 7½ miles including approaches, 2,310-ft. suspension span over the West channel, a tunnel through the hills on Goat Island and a 1,400-ft. cantilever span across the East channel. A description of the bridge will be given in next week's issue. Its total cost is estimated at $70,000,000. Major items of material going into its construction are 170,000 tons of structural steel and wire, 1,000,000 cubic yards of concrete, 20,000 tons of reinforcing steel and 40,000,000 ft. B.M. of lumber. $1,500,000 of construction equipment will be required.

The foundation work on the bridge is estimated at a cost of $15,240,000 and this can be advertised immediately the State Legislature acts upon the contingency specified by the Reconstruction Finance Corporation. Within 30 days after legislative action, three other parts of the bridge will be ready for advertising, the $1,110,000 San Francisco anchorage, the $2,100,000 Goat Island crossing, and dredgings amounting to $240,000. The West Bay superstructure, costing $16,600,000 can be advertised within 60 days after legislative action and the East Bay superstructure within 90 days. The latter is estimated at a cost of $8,900,000.

Special limitations set

It will be necessary for the State of California, through its Highway Commission, to provide the funds in addition to those provided by the Reconstruction Finance Corporation, and to enter into a contract to maintain and operate the bridge throughout the life of the bond in order that the gross revenue of the property may be devoted to payment of interest and the retirement of the bond, according to the stipulations laid down by the R.F.C. when it agreed to make loans for the construction of the bridge. The R.F.C. will purchase bonds of the Toll Bridge Authority from time to time as funds are needed for the construction work.

Exclusion by the R.F.C. of the 3,000-ft. San Francisco approach from its financing may cause delay in starting the work. It is hoped by proponents of the project that this difficulty and that raised by the R.F.C. requirement as to state maintenance and operation can be settled without an abnormally long delay.

Irrigation work

The loan to the Middle Rio Grande Flood Control District is for the continuation of work extending along the Rio Grande for nearly 150 miles near Albuquerque, N. M. Almost $3,000,000 has been spent on the project, including completion of 152 miles of levees, one diversion dam, 20 miles of main canals and 56 miles of draining channels. When completed the project will have 181 miles of levees and four diversion dams. A major item in the work to be done is the construction of a dam 175-ft. high on the Rio Chama, a tributary of the Rio Grande, above Albuquerque, to form a reservoir having a capacity of 198,000 acre-ft., both for irrigation work and flood control. Employment of 2,200 men for three years will be provided. Repayment of the loan is to be by assessment on the property benefited.

Water supply work

The loan of Ogden, Utah, is for the construction of a main water supply line of 26,500 ft. long, construction of a concrete-lined reservoir of 38,000 gal. capacity, 3,600 ft. of 20-in. pipe and 34,800 ft. of 6-in. pipe in the distributing system, and the installation of 2,000 water meters. About 23,000 ft. of 36-in. pipe and 4,800 ft. of 42-in. pipe will be needed for the main supply line.

The loan of Prescott, Ariz., is for the construction of two dams to increase the storage capacity of the water supply system

(Continued on p. 453)

Limited-Dividend Housing Bill Becomes Law in Ohio

A bill providing for the incorporation of limited-dividend housing companies, passed by a special session of the Ohio legislature, was approved by the Governor on Oct. 4. Under the act loans and stock of the company shall not exceed actual money cost of the projects of the company plus 3 per cent for working capital. Dividends are limited to 6 per cent and no stockholder may take out of the investment more than the par value of his stock. The housing companies are given the right of eminent domain but are not exempted from real estate, personal property, income, or security taxes.

A housing board consisting of the director of public welfare, director of commerce, director of public works and four others to be named by the Governor is established by the act.

The purpose of the act is to make it possible for Ohio cities to take advantage of the provisions of the relief act through borrowings from the R.F.C. for slum eradication and housing.

Civil Engineers Name Hammond for President

ALONZO J. HAMMOND, consulting engineer, Chicago, was named official candidate for president of the American Society of Civil Engineers, in a report of the nominating committee to the board of direction at its meeting in Atlantic City, Oct. 3-4. Mr. Hammond has long served the society in important capacities, as director, vice-president, member of the professional conduct committee, and in other offices.

The board passed resolutions honoring the memory of the late Col. John R. Slattery and Charles Warren Hunt. It elected three new honorary members, Lincoln Bush, John E. Greiner, and Charles L. Strobel.

New committees named

Appointment of a committee on the national capital was authorized, to cooperate with similar committees of other societies interested in the development of the city of Washington, particularly with reference to more efficient engineering design. Another committee is to make a preliminary survey to determine the need for a study of tests for hydraulic-fill dam materials.

The board considered two cases of alleged unprofessional conduct, one of which resulted in expulsion. It decided to make no change in districts and zones for next year's voting. Consideration of changes in local-section relations was deferred. J. Vipond Davies and Ralph Budd were named to the Hoover Medal board.

Prize awards to be made at the annual meeting in January were announced as follows: The Croes medal being awarded to D. L. Yarnell and F. A. Nagler for a paper "Effect of Turbulence on the Registration of Current Meters," the Rowland prize to C. A. Betts for "Completion of the Moffat Tunnel," the Laurie prize to E. I. Brown for "The Chesapeake & Delaware Canal," the Wellington prize to Fred Lavis for "Highways as Elements of Transportation," the Collingwood prize to A. R. C. Markl for "The Shannon Power Development." Honorable mention was given to L. G. Straub for his paper "Plastic Flow in Concrete Arches."

Technical division changes

A change was made in the bylaws to shorten the procedure of choosing division executive committee members. Under the new provision the board of direction appoints these members, on recommendation of the divisions. Applying this procedure, the following were appointed, R. V. Black, city planning; A. C. Everham, construction; D. W. Mead, engineering economics and finance; P. M. Tebbs, highway; J. W. Rickey, power; H. E. Miller, sanitary; E. L. Macdonald, structural; William Bowie, surveying and mapping; William J. Barden, waterways.

It was decided that no spring meeting will be held in 1933. The summer meeting will be at Chicago during Engineers' Week in June.

Housing Project for Buffalo

A project, calling for the construction of 600 two-story private homes, to cost $2,000 each, designed for the Polish laboring class of Buffalo, N. Y., has reached the stage where efforts are being made to raise $600,000 as the initial financing. The plans have been drawn by Boehm Brothers, builders. The project is planned as a shortage of homes of this kind is expected in Buffalo next year owing to the lack of residential building during the last two years.

Dredging of Cut-Off in Mississippi River Begun

Dredging of approximately three million cubic yards of earth in a cut-off for the Mississippi river across the Diamond Point peninsula, 15 miles below Vicksburg, Miss., to shorten the main stream channel by 10 miles and lower flood time back water levels two or three feet has been begun. The work is being undertaken by the Second New Orleans District, U. S. Engineers, under the Mississippi River Commission.

The dredge "Raymond" has been put to work on the lower end and the dredge "Catt" will work from upstream. About 200 men are required for clearing the route of the channel.

Many years ago the point was fertile farming land, facing Davis Island on which Greenbrier, home of Jefferson Davis, was located. The main river channel was east of the island between it and Diamond Point, but two years ago the current swung to the west of the island. The project is to be completed in December.

Regulation of Boundary Waters Understudy by Joint Board

Announcement has been made at Ottawa that the international joint commission will hold a public hearing within the next two months to deal with proposals for regulating the waters of Rainy Lake, Namakan Lake and other boundary waters on the border between Ontario and Minnesota. At its semi-annual meeting in Ottawa on Oct. 4, the commission listened to statements by engineers who have looked into the project. Representatives of the Dominion government, the government of the United States, the state of Minnesota, and of private companies interested were present at the meeting.

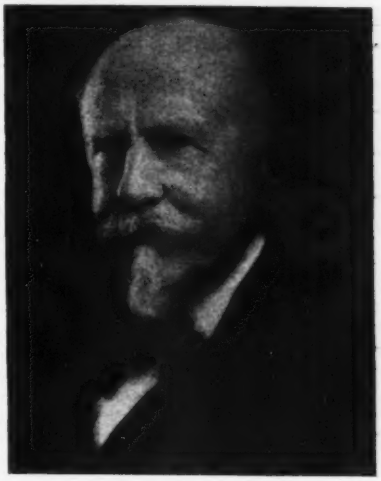
The commission has been asked by the Governments of Canada and the United States to answer certain stated questions bearing on the proposed regulation. Practical questions such as the quantity of land which must be acquired, the cost of necessary works to carry out the regulation and the levels to which the lakes should be raised, enter into the inquiry.

The commission is requested to say what methods of control and operation would be feasible and advisable to regulate the volume, use and outflow of the waters. It is also asked to state what interests on each side of the boundary are benefited by the present storage on Rainy Lake, and by the waters controlled by the dams at Kettle Falls; the nature and extent of such benefits in each case; the cost of the storage, and how such should be apportioned among the various interests benefited.

John Ripley Freeman, Hydraulic Engineer, Dies

John R. Freeman, civil engineer of worldwide note, hydraulic investigator and prominent advocate of hydraulic research, and authority on earthquake phenomena, died at his home in Providence, R. I., on Oct. 6 following an illness of two days caused by heart trouble. Few American engineers are as well known internationally as Mr. Freeman and none have done more toward the development of closer relations among engineers throughout the world.

Born in West Bridgeton, Me., July 27, 1855, Mr. Freeman received his early education there and in Portland, Me., and



John Ripley Freeman

Lawrence, Mass., and graduated from Massachusetts Institute of Technology in 1876. While still in school he spent his summers working in the engineering department of the water company at Lawrence, and upon graduation joined the staff of the company, soon becoming principal assistant to the late Hiram F. Mills, the chief engineer. Doubtless it was this close association with Mr. Mills in his studies of the flow of water, capillarity, friction, etc., that developed Mr. Freeman's natural aptitude for the study of hydraulic phenomena.

Expanding activities

At the time of Mr. Freeman's association with Mr. Mills the latter was engaged as a consultant to various manufacturing companies in Lawrence and other New England centers, and the details of much of that work fell to Mr. Freeman, giving him an intimate knowledge of their problems. This work included daily measurements of the water power used at Lawrence. He also did some independent design work for water power development at Sewall's Falls and Bellows Falls.

After ten years of this work Mr. Freeman decided to enter private practice at Boston, but before the plan was consummated he received and accepted an offer to become hydraulic engineer for the Factory Mutual Fire Insurance Companies. Accepted for only a year as a means of broadening his experience before going into private practice, this contact with the hydraulic problems of fire insurance companies developed into Mr. Freeman's major life work. His experiments in the discharge of fire nozzles, and the hydraulics of fire streams are among the standard investigations of the field. Further, the specifications almost universally adopted for underwriters' fire pumps, nozzles, hose and the like were drawn up by him after extensive experiments.

The success of his efforts in this line brought him greater responsibilities. In 1896 he was elected president and treasurer of the Manufacturers, Rhode Island, and Mechanics mutual fire insurance companies, and in 1903 he was elected to similar office in the State, Enterprise and American.

Public water supply work

Mr. Freeman did not, however, let the fire insurance work make sufficient demands upon his time to preclude continuance of his active participation in engineering matters. From 1894 to 1896 he served as a member of the water board of Winchester, Mass., and in 1896 was appointed one of the original members of the Metropolitan Water Board at Boston. In 1899 Mr. Freeman was selected to report on the water supply of New York. That report and a similar one prepared under his direction for Boston are outstanding examples of complete and comprehensive engineering studies. Subsequently, with Messrs. Burr and Herring Mr. Freeman prepared a report on additional water supply for New York, also a classic.

Upon the organization of the Board of Water Supply for New York in 1905 he was offered the position of chief engineer but declined, accepting the position of consulting engineer.

Other important undertakings include: Consulting engineer, Hetch Hetchy water supply project, 1908-1910; Isthmian Canal Commission, 1909-11; Grand Canal Improvement Board, China, 1917-19; and the Engineering Board of Review, Chicago Sanitary District, 1924.

International contacts fostered

In recent years Mr. Freeman devoted part of his time and a considerable part of his means to the development of international relations among engineers, especially to the dissemination of knowledge of hydraulics and of earthquake phenomena. His most notable contribution to the former was financing the translation of Die Wasserbaulaboratorien Europas and its publication in English under title of Hydraulic Laboratory Practice. A few years ago he established the Freeman Traveling Scholarship through which students of hydraulics are given an opportunity to study in hydraulic laboratories abroad. Mr. Freeman also was one of the most active advocates of the establishment of a national hydraulic laboratory on a scale adequate for any problem that may arise.

Since the time of the San Francisco earthquake Mr. Freeman has taken a keen interest in the determination of those facts in relation to earthquakes that will permit of the construction of earthquake-resistant structures.

In professional society life Mr. Freeman has been active for many years both in the Am.Soc.C.E. and the A.S.M.E. In 1922 he served as president of the former and in 1930 was elected to honorary membership. He was president of the A.S.M.E. in 1905. In all the society work in which he had a part he was liberal both with his time and with his means.

Municipal Officers Conclude Discussion of Sanitary Problems

THE NEED for economy in public works administration continued to be the dominant note in the papers and discussions of that portion of the thirteenth conference of the International Association of Public Works Officials, held in Pittsburgh, Sept. 29, 30 and Oct. 1, that was not reported in last week's issue. The conflicting demands on municipal officials for lower taxes and increased service were pointed out to the conference by Robert B. Brooks, superintendent of streets and sewers, St. Louis, who said that in the last 15 years 60 additional activities in service had been added to the programs of local government. Mr. Brooks urged a regard of government as the business of providing services to the people and pleaded for public works officials to get in line with public opinion in the elimination of waste.

Meeting reduced budgets

The question of street cleaning in relation to reduced budgets was the subject of a paper by H. W. Kueffner, director of public works, Durham, N. C., which was read in Mr. Kueffner's absence by Alfred E. Roche of Troy, N. Y. Mr. Kueffner's paper recommended six methods of reducing street cleaning costs: (1) elimination of the position of helper on a mechanical sweeper; (2) purchase of supplies in larger quantities; (3) discontinuance of the operation of flushers; (4) the discontinuance of night sweeping and assignment of this duty to white wings; (5) the substitution of a shoulder-sack arrangement for the white wings to supplant the push cart; (6) the revision of sweeping schedules to eliminate dead mileage. The cost of sweeping at Durham decreased from 79½c. per thousand square yards in 1921 to a figure between 12 and 15c. per thousand subsequent to 1921, when the first motor pick-up sweeper was purchased and put into operation. This figure is exclusive of depreciation which the Durham experience indicates should be 2½c. per thousand square yards. In Durham, the use of a vacuum type sweeper to replace the flusher was a disappointment in operation and was abandoned after a few months. By changing from a coarse broom filler to the very fine cuts they were able to eliminate the flusher.

Contract and municipal garbage collection

Covington K. Allen, assistant engineer of street cleaning, Baltimore, Md., describing modern methods of garbage collection, in a paper read by R. B. Brooks, St. Louis, in Mr. Allen's absence, wrote: "Modern equipment, which consists of enclosed vehicles and proper regulation of service, handled by an efficient force, are the essential features for modern methods. With these main essentials to begin with, it is quite possible that better cooperation will be given by the public and they will lend their efforts in making this service thoroughly modern."

This paper precipitated a discussion on the relative merits of contract and municipal collection systems. In response to a question by Wm. J. Galligan of Chicago, B. L. Crozier, chief engineer of the Department of Public Works of Baltimore, said that the cost of rubbish collection in Baltimore was $4.10 per ton by contract and the cost of garbage collection, which is done by the city was $3.18 per ton, exclusive of depreciation and overheads. Messrs. Costigan of Washington, Carrigg of Sioux City, Ia., and Dunbar of Ottawa, Ont., spoke in favor of municipal collection. Mr. Dunbar said that Ottawa had had experience with contract collection and was forced to go back to the municipal service on demand of the rate-payers. Municipal collection in Ottawa, he said, has been costing slightly more but there have been fewer complaints. Grant Cook of Youngstown said that the contract method was very satisfactory in his city.

Refuse collection in Europe

Donald C. Stone, director of the committee on uniform street and sanitation records, reported on a four-month visit to Europe and England, where he said they aimed for salvage in refuse collection and disposal. Even with the serious decline in prices, they are making salvage pay, due to their methods of intensive study of material available and possible markets. He attributed the success of "controlled tipping" in England to careful attention to detail in raking and laying the refuse. Temperature control in controlled tips is attained by proper covering. The temperature of the material dumped will be 140 deg. at the end of three to four days, and 180 deg. in from three to four weeks, from which point it descends in about six months to the temperature of the surrounding ground.

Charges for equipment use

Gustave A. Moe of Chicago read a paper on the handling of payrolls and equipment and declared that rental rates were the only fair basis for charging for the use of equipment. Distributing actual monthly expenditures may distort unit costs as much as 35 per cent. He believed that smaller cities should centralize equipment control in their department of public works.

Dust laying on streets

A paper by C. E. Sawyer, Jr., city engineer of Traverse City, Mich., read in Mr. Sawyer's absence by E. A. Miller of Rochester, N. Y., described experiments on the use of calcium chloride as a dust preventive in Midland, Mich., in which the Dow Chemical Co. cooperated. These experiments revealed that calcium chloride is found close to the surface of the roadway after application, or after lengthy periods of dry weather. When rain falls it is carried well below the surface and after the rain stops again the calcium chloride once more rises, the rise being "promoted by capillarity or wick-like properties of the soil materials and continues until the strength of the solution at the surface is such that it can no longer lose water to the air under existing humidity conditions. Because of the presence of calcium chloride at the surface in dry weather, machine maintenance should be eliminated except during or after rains. Otherwise, the calcium chloride may be lost." The paper recommended also the elimination of loose stones on the surface of a gravel road because their movement abrades and punches holes through the surface resulting in loss of calcium chloride.

A report of the other paper presented at the meeting was published Oct. 6, p. 417.

Refuse and Garbage Destructors for Detroit Under Consideration

Plans and specifications for the four garbage and rubbish incinerator plants to be built in Detroit are being studied by incinerator builders. A proposal has been made by the city that such a company build and operate the plants for seven years charging a price per ton sufficient to enable it to earn their investment and profits over seven years and to surrender the plants to the city at the end of that period. The four plants to be located in various sections of the city would range from 200 to 600-ton units and have a combined capacity of 1,800 tons.

At a meeting with the city council representatives of the interested companies indicated that they considered the plan practicable and that they are ready to bid.

The Reconstruction Finance Corporation is considering Detroit's request for a loan to construct the incinerators, according to word received by George B. Walbridge, chairman of the Michigan Committee for Trade Recovery.

Merced Irrigation District Studies Basis of Refinancing

With a fact-finding survey well advanced which will provide basic data for refinancing negotiations, the Merced (Calif.) Irrigation District has been forced to announce an $8.90 tax rate in an effort to meet defaulted interest payments. The rate is a high record for the District and is based on an assessment roll of $12,873,000, which is $6,287,000 less than last year, when the tax rate was $5.60 although the resulting annual revenue is about the same. Requirements for fixing irrigation district tax rates are dictated by state law, which requires officials of a district to levy a tax sufficient to produce an income to cover all debts and expenses of the district, not only for the ensuing year, but also for all past debts. Naturally, any district in default on its obligations automatically receives a seriously increased tax rate as a result.

About a year ago, after the Merced District had defaulted temporarily on its $16,000,000 worth of bonds in July, 1931, negotiations were started between the board of directors of the district and a bondholders' protective committee to effect a basis of compromise for refinancing. The negotiations did not prove successful.

Subsequently the landowners in the district formed an advisory committee to assist the directors in handling the problem. This committee proposed the selection of a negotiator from outside of the district.

The first tangible result of this new set-up was an arrangement between the district and a group of bondholders to ascertain facts for a sound appraisal of the ability of the land to pay for water and other charges. A fact-finding committee was selected to make investigations and is now actively at work and expects to report by the end of the year. The investigation includes: (1) An economic survey to find actual facts concerning receipts and expenditures from a large number of typical farms, and (2) an accurate appraisal of land values. The appraisal of the land is being done jointly by representatives of the landowners and bondholders, while the

economic survey is being conducted by the agricultural experts. Merced is the first district in California to undertake such a cooperative program of investigation between landowners and bondholders with the assistance of the state's agricultural authorities.

The district has outstanding $16,250,000 worth of bonds, at 5½ and 6 per cent. In addition it has assumed the payment of a small amount of drainage district bonds, bringing the total bonded indebtedness to $85.90 per gross acre, the heaviest bonded debt of any irrigation district in the state.

The first small default in interest payment occurred in July, 1931, but was soon lifted. A larger default occurred six months later, but in time this was also cleared up. However, on July 1, 1932 the district was forced to default on $330,000 out of $477,000 of bond interest. A part of this amount is being paid from power revenue, but it is estimated that almost $150,000 of back interest will be unpaid on Jan. 1, 1933, when $477,000 additional bond interest and the first installment of principal ($60,000) will be payable. The delinquency in tax payments for the year ending June, 1932, was reported as 38.4 per cent.

SOCIETY CALENDAR

AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS, annual meeting, Washington, D. C., Nov. 14-18.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, annual meeting, Pittsburgh, Pa., Oct. 20-21.

AMERICAN PUBLIC HEALTH ASSOCIATION, annual meeting, Washington, D. C., Oct. 24-27.

AMERICAN SOCIETY OF MUNICIPAL ENGINEERS, annual meeting, Detroit, Mich., Jan. 16-20.

ASPHALT INSTITUTE, Asphalt Paving Conference, New Orleans, La., Dec. 5-9.

HIGHWAY AND BUILDING CONGRESS participated in by fourteen national engineering societies and trade associations, Detroit, Mich., Jan. 16-20.

INTERNATIONAL CITY MANAGERS ASSOCIATION and GOVERNMENTAL RESEARCH ASSOCIATION will hold a joint annual conference at Cincinnati, Ohio, on October 24 to 26.

NATIONAL ASSOCIATION OF RAILROAD AND UTILITIES COMMISSIONERS, annual meeting, Hot Springs, Ark., Nov. 15-18.

NORTH CAROLINA SECTION, AMERICAN WATERWORKS ASSOCIATION, and the NORTH CAROLINA SEWAGE WORKS ASSOCIATION will hold a joint meeting at Winston-Salem, Oct. 31-Nov. 2.

Sale of Appropriated Water By Wyoming Cities Prohibited

Municipalities receiving their water supply under town or city appropriations may not sell water to persons outside of the city limits, according to a ruling made recently by the attorney-general of Wyoming. The question was raised by the city of Douglas, Wyo., which sought to sell some of its surplus water to persons residing adjacent to its supply system. The attorney-general ruled that such surplus was the property of the state.

Reconstruction Loans

(Continued from p. 450)

and to reduce pumping costs during dry periods. The total estimated cost of the dam is $135,000 with $28,000 additional for a diversion dam. The R.F.C. will purchase 5 per cent general obligation serial bonds of the city, the loan to be secured by the water supply property.

The Twin Lakes Reservoir & Canal Co. of Ordway, Colo., has applied to the R.F.C. for a loan of $2,000,000 to construct a water diversion project from Roaring Fork on the west side of the continental divide into the Arkansas River on the east side. The project calls for one tunnel 3.8 miles long and another 1.7 miles long.

The construction of a sewage disposal plant at Jackson, Mich., at a cost of $305,000 is proposed in a loan application made to the R.F.C. by the city.

The town of Heavener, Oklahoma, has applied to the R. F. C. for a loan of $30,000 for improvement of its water works system.

The city of Hancock, Mich., plans to apply to the R.F.C. for a loan of $150,000 for the construction of a water pipe line to supplement its supply system.

Philadelphia-Camden bridge

The Delaware River Bridge Commission hopes to obtain $8,000,000 from the R.F.C. for the construction of a high-speed line over the Philadelphia-Camden Bridge. The commission applied to the R.F.C. some weeks ago for a much larger loan to refinance its outstanding loan, but the use of funds for refinancing purposes under the relief act is not approved by the directors.

The construction of a bridge across Lake Chautauqua at Bemus Point is proposed by the Chamber of Commerce of Jamestown, N. Y., and an application to the R.F.C. is proposed.

Preparation of plans for a bridge over the Ohio River at Owensboro, Ky., and application to the R.F.C. for a loan of $1,500,000 has been determined upon by the Kentucky state highway department. Application for a permit will be made to the War Department.

The legality of a bond issue of $320,000 for the construction of a sewerage system at Hopkinsville, Ky., is being tested in order to clear the way for an application to the R.F.C. for a loan secured by the bonds.

The city of Covington, Va., is making application for a loan of $375,000 for the construction of a Municipal Power & Light Plant.

Purchase of the present water supply system and its expansion at a cost of $25,000 is planned by the town of Clintwood, Virginia.

Refunding of loans

Consideration is being given at the Reconstruction Finance Corporation to a plan under which borrowers may be refunded a part of their interest charges in the event the loan is refinanced at a lower rate of interest. If money is loaned for a construction project at 5 per cent and later the loan is lifted and replaced with a private agency at 4½ per cent, the corporation would refund the one-half per cent additional interest paid on the amount borrowed from the corporation, thus making the interest rate 4½ per cent for all the money used in the project.

It is known that this is receiving favorable consideration, as it offers an inducement to borrowers to get their loan into private channels at the earliest possible time.

In connection with the 5 per cent rate of interest which has been charged on all self-liquidating loans made to date, it is pointed out that there are no payments of commissions, bonuses or brokerage.

The legal division of the corporation has rendered an opinion that assessments based on benefits such as usually are made in connection with irrigation and drainage projects, do not constitute tax within the meaning of the act. The policy of the corporation evidently will be to allow liquidation through assessments where the vote authorizing the charge is substantially unanimous.

Personal Notes

W. D. WILLIAMS, division engineer, Northern-Springfield Division, Cleveland, Cincinnati, Chicago and St. Louis Railway, has retired from active service. C. W. ENGLE has been appointed division engineer to succeed him. His headquarters will be at Van Wert, Ohio.

WM. GUY WILLIAM and THOMAS E. BROWN, JR., formerly associate engineers in the firm of Waddell & Hardesty, have entered into partnership under the name of Williams & Brown to practice as consulting engineers specializing in the design of fixed and movable bridges. Their office will be in New York.

GEORGE F. ECKHARD, professor of structural engineering at the University of Vermont since 1915, has been appointed dean of the college of engineering to succeed the late Josiah W. Votey. Professor Eckhard has been acting as dean since Dean Votey's death. He is a graduate of Iowa State College in 1905. After graduation he served as professor of civil engineering at the New Mexico School of Mines and at James Milliken University, and as associate professor of structural engineering at Penn State College.

Obituary

JOHN T. MCKNIGHT, former city engineer of Rockville, Conn., died at his home in Ellington, Conn., on Oct. 3, age 72 years.

WILLIAM G. WESTON, member of the firm of Weston & Ellington, architects and engineers, Detroit, Mich., died at Detroit on Sept. 19 after a short illness.

EDWARD M. GRAVES, president of the Central Dredging Co., Chicago, died at his home in Lake Forest, Ill., on Oct. 1. During the World War he was lieutenant colonel of the 529th Engineers and was in charge of the construction of water-works at Brest, France, for the American Expeditionary Forces. Colonel Graves, who was 55 years old, was a member of the American Society of Civil Engineers.

ROBERT LEE FARIS, assistant director, U. S. Coast and Geodetic Survey died suddenly at his home in Washington on Oct. 6, aged 64 years. He had been with the Survey 41 years and assistant director for 18 years. Capt. Faris graduated from the University of Missouri in civil engineering in 1890. At one time he served as a member of the Mississippi River Commission. He was retired in January of this year but was immediately recalled to active duty.

Brief News

A MEMORIAL TABLET in honor of Isaac Allen, noted bridge builder of the Revolutionary period, was recently unveiled at West Groton, N. Y.

A RAINFALL of 9.8 in. is reported to have fallen in Woonsocket, R. I., on Sept. 17 when the tropical storm moving up the coast passed over that city. The fall continued from early morning until late at night.

HAND-LABOR REQUIREMENTS of highway work in Colorado are reported to have resulted in an increase of from 10 to 25 per cent in bids recently received for highway work as compared with bids that would have been possible had it been possible to use machines.

IRRIGATION PUMPING EQUIPMENT along the lower Rio Grande valley was seriously damaged by flooding during the recent high water period. Many plants suffered from inundation. Despite the sealing of pits and other efforts to protect the plants much sand and silt was washed into them.

DECKING THE RAILWAY BRIDGE of the Ottawa and New York Ry. across the St. Lawrence River at Cornwall, Ont., in order to make it serviceable for vehicular traffic has been taken up by the Board of Trade of Cornwall. At the present time there are no highway bridges across the St. Lawrence River above Montreal.

AT A COST OF $15,000 the Memorial auditorium at Louisville, Ky., a plant costing nearly a million dollars, has had its acoustic properties corrected. The work was carried out under the direction of F. R. Watson of the University of Illinois and Paul E. Sabine, head of the Riverbanks Laboratory, Geneva, Ill. Insulation tiles absorbing approximately 80 per cent of the sound have been installed, wall angles and domes changed.

A RESURVEY OF BASE LINES in the Detroit area is in progress under the direction of the U. S. Coast & Geodetic Survey. Thirty men are employed on the work which was undertaken at the request of Joseph C. Stringer of the Engineering Department of the city because of the difficulty involved in making surveys there under existing conditions.

A HOLIDAY IN HIGHWAY CONSTRUCTION is proposed in a resolution recently adopted by the Board of Trustees of the Ohio Farm Bureau Federation. The trustees also call for a legislative study of the question of highway assessments.

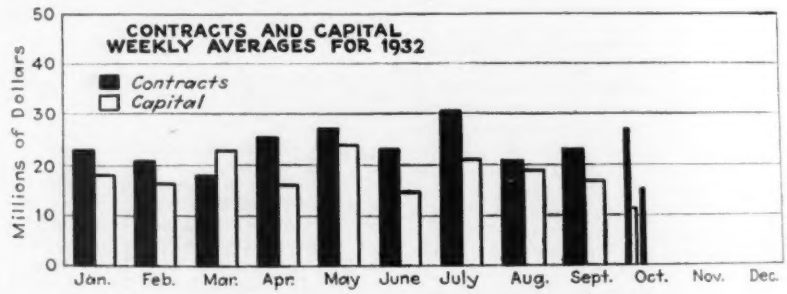
CONSTRUCTION OF A HYDROELECTRIC POWER PLANT on the Mississippi River at the Chain of Rocks in the extreme northern edge of St. Louis is being vigorously opposed by farm interests in Missouri and Illinois. Application for a preliminary permit for a dam at this point was filed recently with Federal Power Commission by Carl G. Stifel, president of the John H. Gundlach Realty Co. of St. Louis (*ENR*, July 23, p. 118). It is stated that wide areas of fertile farm land would be flooded by the proposed dam.

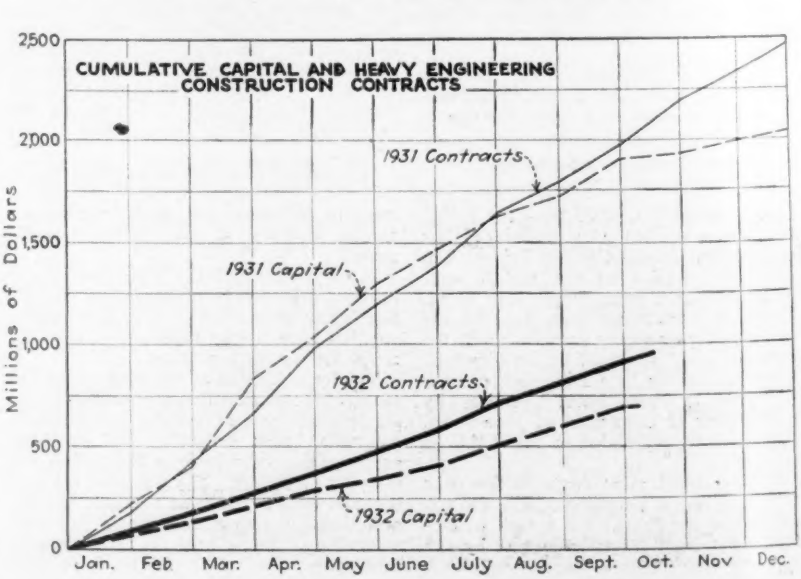
A COURSE OF HOME STUDY in highway construction and maintenance has been inaugurated by the University Extension Division of the Massachusetts Department of Education. The course is stated to be as non-technical as is consistent with a thorough and authoritative presentation of the subject. It covers the major types of pavement construction and designs. The charge for the course is $5 to residents of Massachusetts and $10 to non-residents with an extra charge of $4 for the textbook.

Engineering Contracts and Capital

ENGINEERING CONSTRUCTION contracts reported for the past week total $14,927,000, as compared with $27,000,000 for the previous week. However, the current figures are not for a full week because of early closing of these pages, due to a Columbus Day holiday, and are therefore not strictly comparable with records of other weeks. In the above short-week figures, 11.3 millions represent public contracts, while private awards amount to 3.6 millions. Highway lettings totaled $5,400,000. Federal contracts were $3,400,000. No single contracts of more than $1,000,000 were reported during the week.

New capital issues for the week totaled $11,314,000, all public issues. The largest issues reported were State of Massachusetts Metropolitan District sewerage and water bonds, $3,465,000, and Syracuse, N. Y., bonds for general improvements, $2,330,000.





Contracts and Capital

CONSTRUCTION

(Thousands of Dollars)

	Weekly Average Oct., 1931	Oct. 1932	Week Oct. 13, 1932
Federal government	$ 4,705	$3,275	$3,353
State and municipal	21,823	12,443	7,998
Total public	$26,528	$15,718	$11,351
Total private	29,765	5,292	3,576
Week's total	$56,293	$21,010	$14,927
Cumulative, Jan. 1 to date:			
1931 construction			$2,077,700
1932			956,714

Decrease, 53 per cent.

NEW PRODUCTIVE CAPITAL

(Thousands of Dollars)

	Weekly Average Oct. 1931	Sept. 1932	Week Oct. 8 1932
Total private and public	$6,200	$16,500	$11,300
Cumulative, Jan. 1 to date:			
1931 new capital			$1,907,800
1932 new capital			687,600

Decrease 64 per cent.

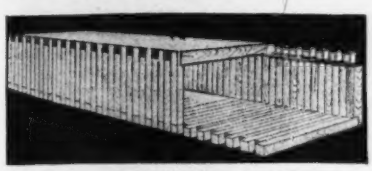
ENR Cost and Volume Index

Cost		Volume	
October, 1932	159.16	**Sept., 1932**	124
September, 1932	157.96	August, 1932	111
October, 1931	169.78	Sept., 1931	225
1931 (Average)	181.35	1931 (Average)	220
1930 (Average)	202.85	1930 (Average)	260
1913 Average	100.00		

Construction Equipment and Materials

Culvert of Laminated Wood

Culverts built of laminated wood are announced by the Wheeler Lumber Bridge & Supply Co., Des Moines, Iowa. They are made of pressure-treated or natural rot-resisting woods. Each culvert is completely assembled at the factory and then taken apart for shipment. The manufacturer states that the laminated wood culvert is particularly well adapted where low headroom conditions exist. They are manufactured in square and rectangular sizes from 12x12 in. to 60x60 in. The timber used is either creosoted southern yellow pine or redwood or hard structural redwood. Each laminated strip is cut to length, framed, then assembled into culvert sections about 4 ft. long. Each strip is spiked to the adjoining strip with specially designed nails. Any required size or length of culvert is constructed into one continuous unit by using the separate sections in assembly.



Timber culvert assembled at the factory and shipped in 4-ft. sections

Mechanical Spreader for Retreading Roads

A mechanical spreader and surfacer for retreading roads is being manufactured by the Heltzel Steel Form & Iron Co., Warren, Ohio. The unit is self-propelling by a winding cable on drums mounted on each side. After the cables are completely wound, the machine is stopped and the cables are again stretched along each side of the roadway and anchored by plates through which stakes are driven into the road.

The machine distributes the windrow material evenly over the width of the roadway. A blade in front of the machine mixes and distributes the material in the windrow to a V-shaped spreader and leveler which splits the windrow and spreads the material out to the wide runners set to the desired width of the road. By adjustable hand screws the operator is able to distribute the material, so that there is an even amount of material piled in front of the screed. The spreader moves forward under normal conditions at the rate of 12 to 15 ft. per min. The drums are operated together on straight work and independently to negotiate curves. The side runners are of sufficient length to prevent dips in the finished surface.

Mechanical surfacer distributes windrow material evenly over roadway.

New Equipment in Brief

Synchronous Motor. A new synchronous motor developed for industrial and general purpose applications is announced by the Ideal Electric & Manufacturing Co., Mansfield, Ohio. The new unit, designated as the "Self-Syn" motor, requires no external excitation, the exciter winding, direct current commutator, etc., being integral with the motor itself. The motor is started with a hand-operated compensator in the same manner as an ordinary induction motor. The motor possesses the ability to re-synchronize itself automatically after having been pulled out of step by a line voltage dip or a momentary overload.

Bolt Anchor. A one-piece, heavy-duty, double expanding masonry anchor for bolts is announced by the Rawlplug Co., Inc., New York, N. Y. A double inverted cone body of aluminum is employed as the expanding factor. The ductile aluminum collars, top and bottom, spread upon being caulked and completely seal the hole, preventing the lead from flowing under a load pull. The bolt will not turn in the hole as the bolt head imbeds itself in the aluminum.

Welding Shield. A welding operator's head shield, embodying a movable protective lens which allows the operator clear vision without raising the shield, is announced by the Lincoln Electric Co., Cleveland, Ohio. The protective lens is held in place in a vertical slide by a spring. Slight pressure with the chin of the operator on an aluminum rest raises the lens and allows the operator to view the work or change electrodes. When pressure is removed, the lens automatically falls back into place. A stationary cover glass guards the inner lens against spatter and also protects the operator from flying sparks in case the movable lens is accidentally raised.

Dragline Bucket. The Bucyrus-Erie Co., South Milwaukee, Wis., has announced the Red Arch dragline bucket, Type X. It is a general utility bucket for the average run of dragline work and is built in sizes from ½ to 8 cu.yd. The feature of the bucket include construction from a one-piece, annealed steel casting, and a manganese steel lip with renewable manganese steel teeth. The tooth bases are cast integral lips.

Special Dredge. A special dredge with the cutter machinery designed to swing independently of the hull is reported by Morris Machine Works, Baldwinsville, N. Y. In operation the hull is to be held stationary by means of two side spuds and one rear spud. This rear spud will also be used as a kicking spud for advancing the dredge forward. With this arrangement of the cutter machinery, it will be possible to make a cut 14 ft. deep, 30 ft. wide at the surface, and 24 ft. wide at the bottom. The dredge has been designed for use in widening and deepening the Grand Canal of the Valley of Mexico. Its special features were necessitated by the narrow width of the canal.

Unit Heater. The Murray Iron Works Co., Burlington, Iowa, has placed on the market a line of unit heaters provided with steam-turbine-driven fans to be operated at steam-inlet pressures. About two-thirds of the amount of steam supplied the heater passes through the turbine and then to the heater coil. The heat is controlled by a thermostat control valve.

New Publications

Centrifugal Pump. Multistage centrifugal pumps with single suction impellers are described in catalog B-5, distributed by the De Laval Steam Turbine Co., Trenton, N. J. These pumps are built with as many as seven stages in one casing and for heads up to or exceeding 1,600 lb. per sq.in. The distinguishing features of design include horizontally split casings with one piece diaphragms, labyrinth wearing rings and a hydraulic system providing for axial thrust.

Zeolite. The application of zeolite water softeners to the treatment of boiler feed water is described in a 36-page booklet just published by the Permutit Co., 440 Fourth Ave., New York. It is illustrated with photographs and diagrams and contains tabulated data, conversion tables, factors, reactions, etc. Copies may be obtained free upon request to the company.

Copper and Brass. The semi-annual issue of the catalog of Revere Copper and Brass Incorporated was published on July 1. It consists of 76 pages of information regarding the products of the company, including sheets and plates, drawn and extruded shapes, tubes and pipes, and forgings. In connection with copper pipe for water services, two basic types of compression joints are described.

Iron Pipe. "Long Service from Armco Ingot Iron Pipe" is the title of a booklet describing the characteristics of pure iron for use in pipe lines. Engineering data are given for spiral welded, straight seam welded, riveted and lock bar pipe. In addition, the general characteristics of the material, uniformity, rust resistance and weldability are given discussion.

Water Tanks. A description of ellipsoidal bottom elevated steel tanks, together with a set of standard specifications, is contained in a recent booklet published by the McClintic-Marshall Corp., Bethlehem, Pa. A table of standard dimensions for tanks varying in capacity from 5,000 to 2,000,000 gal., and varying in height from 25 ft. to 150 ft., is included.

Current Construction Unit Prices

Widespread Bids for Excavation, Illinois

AN UNUSUALLY wide range in bidding was revealed in opening bids for the construction of the Goose Lake drainage project, Grundy County, Illinois, by the U. S. Engineer Office in Chicago. Sixteen bids ranged from a low of $8,995 to a high of $33,830. Engineer's estimate was $19,360. The work comprises construction of a levee, excavation of a reservoir and ditches, elevation of grade of a highway, construction of a culvert and appurtenant work. Contract was let in July to the low bidder, L. E. Meyers Co., Chicago. Lt. Col. Dan I. Sultan is district engineer.

Following are list of bidders, quantities and complete unit pirces of all bidders, given to show the spread in bidding.

List of Bidders:

No.	Firm Name and Address	Total Bid
1.	L. E. Meyers Co., Chicago	$8,995
2.	Wm. Kubinski, Joliet, Ill.	9,560
3.	Gjellefield Const. Co., Elmhurst, Ill.	9,760
4.	H. B. Whitney Co., St. Charles, Mo.	12,648
5.	Congress Const. Co., Chicago	12,739
6.	D'Andrea & Valente, Chicago Heights	12,875
7.	U. S. Builders, Inc., Chicago	13,874
8.	L. A. Wilson & Co., Inc., Ottawa, Ill.	14,083
9.	Harshman & Jarrell, Frankfort, Ind.	14,234
10.	Cope & Fisher, Decatur, Ill.	14,636
11.	T. H. Iglehart Co., Chicago	14,949
12.	Powers-Thompson Const. Co., Joliet	15,198
13.	Thos. M. Madden Co., Chicago	16,435
14.	E. L. Archibald Co., Chicago	19,777
15.	Central Const. & Eng. Co., Milwaukee	23,810
16.	R. C. Huffman Const. Co., Cleveland	33,830
17.	Government Estimate	19,360

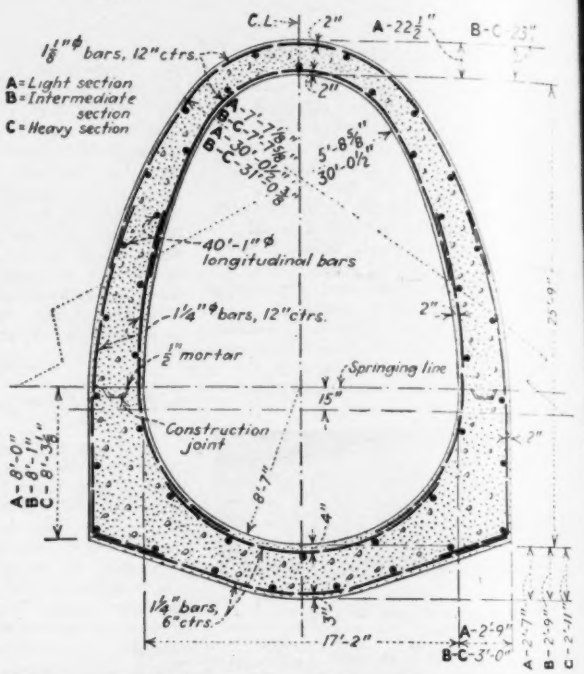
No.	Item	Unit	Quan.
A.	Excavation	Cu.Yd.	28,000
B.	Embankment	Cu.Yd.	10,300
C.	Soiling	Sq.Yd.	3,500
D.	Backfill	Cu.Yd.	650
E.	Concrete	Cu.Yd.	40
F.	Reinforcing steel	Lb.	2,500
G.	Gravel road surfacing	Cu.Yd.	450
H.	Stone paving	Sq.Yd.	1,600
I.	Guard fences	Lump sum	.....

Bidder No.	Unit Prices, Items A	B	C	D	E	F	G	H	I
1	$0.13	$0.23	$0.10	$0.90	$16.75	$0.03	$0.88	$0.55	$30
2	.15	.225	.07	.1755	15.20	.05	1.50	.75	75
3	.12	.15	.15	.20	12.00	.03	2.50	1.50	120
4	.14	.25	.20	.15	15.00	.05	1.20	2.50	90
5	.15	.27	.18	.30	17.00	.05	.24	2.00	820
6	.15	.25	.30	.25	16.00	.03	2.00	2.00	*
7	.10	.23	.18	.35	14.00	.035	3.00	3.50	250
8	.20	.40	.10	.25	15.00	.06	2.00	1.25	200
9	.14	.42	.12	.40	18.00	.04	2.40	2.10	48
10	.185	.26	.08	.35	14.50	.035	2.45	2.75	100
11	.30	.32	.20	.12	12.00	.04	2.60	.40	85
12	.25	.25	.10	.25	20.00	.04	2.00	2.00	110
13	.20	.40	.50	.50	25.00	.05	2.50	1.40	150
14	.30	.60	.30	.50	16.80	.04	3.00	1.00	100
15	.45	.55	.20	.20	20.00	.10	1.70	1.50	500
16	.50	.60	.40	1.00	35.00	.10	1.00	5.00	1500
17	.40	.25	.25	.20	17.00	.08	1.00	2.00	50

*75c. per lin.ft.

Section B, Louisville, Ky., Outfall Sewer

SECTION B, the second section of Southwestern Outfall Sewer, Louisville, Ky., was placed under contract September 16 by the Commissioners of Sewerage of Louisville for a net total of $778,272, or $789,542 gross when considering 225 working days at $50 per day, the award going to S. A. Healy, Davenport, Ia. Bids were received from 14 contractors, the highest net bid being $1,186,608; the highest gross, $1,202,608. The project consists of 5,443 lin.ft. of 17ft.2in.x25ft.9in. reinforced concrete inverted egg sewer in trench 47 to 71 ft. below original ground surface. Besides the excavation, principal quantities consist of: concrete, 44,700 cu.yd.; reinforcing, 6,600,000 lb.; lead in contraction joints, 81,000 lb. A cross-section of the sewer is shown in the accompanying illustration. Light, heavy and intermediate sections refer to thickness of shell, varying with depth of backfill. This project is the 23d of a series of sewers to be constructed from the proceeds of a $10,000,000 bond issue approved Nov. 6, 1928. Woolsey M. Caye is technical engineer for the commissioners.



Typical cross-section, Section B, Louisville outfall sewer. Light, intermediate and heavy sections refer to thickness of shell. Total lengths: light, 2,017 ft.; intermediate, 864 ft.; heavy, 2,562 ft.

Following are complete unit prices of the three low bidders. Concrete items 1b and 1c are for curved sections of the sewer. (A) S. A. Healy, Davenport, Ia., contract; (B) The Arundel Corp., Baltimore; (C) Louisville Constructors, Inc., Louisville. Item 9b covers laying of the small pipe with plastic compound, as an alternate to Item 9a, but all bidders figured lower for the cement mortar.

Item	Quan.	Unit Prices A	B	C
1. Exc. and backfill, lin.ft.	5,499	$44.00	$36.70	$47.00
3a. Class A concrete, c.y.	43,270	8.00	8.25	8.00
3b. Class A concrete, c.y.	720	9.00	15.00	12.22
3c. Class A concrete, c.y.	770	10.00	15.00	14.60
3d. Class C concrete, c.y.	100	7.00	8.00	9.60
4a. Brick masonry, c.y.	50	25.00	20.00	22.25
4b. Vitrified brick lining, s.y.	1,060	3.00	3.25	3.90
5a. Reinforcing, lb.	6,620,000	.0235	.028	.026
5b. Dowels, lb.	24,700	.023	.05	.024
8. A.S.T.M. clay sewer pipe				
24 in. and smaller, $3,358	....	60%	60%	60%
27 in. and larger, $632	....	40%	55%	50%
9a. Laying above, cement mortar				
6-in., ft.	10	.25	.25	.25
8-in., ft.	10	.30	.30	.30
10-in., ft.	10	.35	.35	.35
12-in., ft.	10	.40	.40	.40
15-in., ft.	10	.45	.45	.45
18-in., ft.	320	.50	.50	.50
21-in., ft.	10	.60	.60	.60
24-in., ft.	452	.70	.70	.70
27-in., ft.	10	.85	.85	.85
30-in., ft.	48	1.00	1.00	1.00
33-in., ft.	10	1.20	1.20	1.20
36-in., ft.	10	1.40	1.40	1.40
9b. Laying same, plastic compound				
6-in., ft.	10	.40	.40	.40
8-in., ft.	10	.45	.45	.45
10-in., ft.	10	.50	.50	.50
12-in., ft.	10	.55	.55	.55
15-in., ft.	10	.60	.60	.60
18-in., ft.	320	.70	.70	.70
21-in., ft.	10	.80	.80	.80
24-in., ft.	452	.90	.90	.90
27-in., ft.	10	1.05	1.05	1.05
30-in., ft.	48	1.20	1.20	1.20
33-in., ft.	10	1.40	1.40	1.40
36-in., ft.	10	1.60	1.60	1.60
15a. Asphalt macadam pave., s.y.	300	2.00	2.25	2.00
15b. Waterbound macad. pave., s.y.	220	2.00	2.00	1.00
16. Lead seal stripe, lb.	81,200	.14	.23	.16
Net total		$778,292	$794,994	$819,642
Progress, $50 per day, no. days		300	365	300
Gross total		$789,542	$809,994	$837,802